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ABSTRACT

This manual supplies information helpful to individuals wishing to become certified in public health pest control. It is designed as a technical reference for vector control workers and as preparatory material for structural applicators of restricted use pesticides to meet the General Standards of Competency required of commercial applicators. The vectors discussed in detail include mosquitoes, flies, fleas, lice, ticks and mites, venomous arthropods, and rodents. Each section is accompanied by pictorial keys to larvae and adults. (CS)

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PUBLIC HEALTH PEST CONTROL

STATE OF ARIZONA

HONORABLE RAUL CASTRO, GOVERNOR

MARCH
1977

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PREFACE

This training manual was prepared for use by those persons wishing to become certified in the category of Public Health Pest Control as required by the Federal Insecticide, Fungicide, and Rodenticide Act of 1972, Title 3, Chapter 2, Article 6.1, Arizona Revised Statutes; and the Arizona State Plan for Certification of Applicators of Restricted Use Pesticides. In accordance with the functions of the Arizona Department of Health Services as described in Section 36-132 to train and provide technical consultation, the manual has been expanded beyond the Specific Standards of Competency required for certification and is intended to be a technical reference for Vector Control workers in the State.

We have used material from the excellent pictorial keys and other information provided by the United States Public Health Service Center for Disease Control and wish to acknowledge them. I would like to thank Dr. Roger Gold and Dr. Gary Olton of the University of Arizona for their review of the technical material of the manual, Katherine Hobson for her patient suggestions in syntax and grammar, Mr. Barry Abbott, Section Manager, and Section personnel, Jim Douthit and Mike Wright, for their assistance in preparing this manual.

This manual was printed with funds provided by an EPA grant and is intended to supplement the core manual, "Certification Training Manual for the Structural Pesticide Applicator", formulated by Kellogg West, California State Polytechnic University, Pomona, California, and reproduced by the Council for Environmental Studies, College of Agriculture, University of Arizona, Tucson, Arizona. The manual is used to prepare structural applicators of restricted use pesticides to meet the General Standards of Competency required of commercial applicators.

March 1977

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MOSQUITOES

I. INTRODUCTION

Mosquitoes are the most important group of vectors encountered by Public Health Vector Control Biologists. More time, money, and effort is consumed preventing or eliminating them than all the other vectors in the State of Arizona. Any water that contains emergent vegetation or organic debris and stands long enough to permit completion of the immature stages of development can contribute to the mosquito population. Man's intrusion into the country with farms, golf courses and subdivisions has not diminished the mosquito problem. In fact, generally, urbanization brings with it an increased vector problem due to the variety of mosquito habitats and the proximity of human populations.

Mosquitoes are of consequence in Arizona due to their annoying biting activity, but are extremely important in harboring and transmitting several neurotropic viruses that are capable of producing disease in man and horses.

II. IMPORTANCE

The importance of mosquitoes to man's existence cannot be limited to its disease transmitting abilities. The bites of the female mosquito, which is the only sex that takes blood, are a very real problem to many persons.

Livestock are greatly bothered by mosquito bites, and also are responsible for contributing new breeding sites by tracking through marshy ground. Several mosquito species utilize the hoofprints for larval breeding sites.

A. BITES

When a mosquito bites, it secretes saliva containing an anticoagulant into the wound. The anticoagulant prevents blood clotting and acts as a proteinaceous foreign antigen to the animal's immune system. Initial reaction to the foreign substance is an itching and reddening followed by swelling of the site. Scratching of the bite may often result in secondary infection of the wound.

B. DISEASES

1. ENCEPHALITIS

In Arizona, disease transmission by mosquitoes is primarily limited to four types of encephalitis. The term encephalitis means "inflammation of the brain" which characterizes the type of symptomology that shows up when a human (or in some cases, a horse) is infected with a certain virus. Not all types of encephalitis causing viruses are arthropod-borne.

The encephalitides are caused by viruses called 'Arboviruses' or 'Arthropod-borne Viruses' which are picked up by mosquitoes in the blood of infected host animals, then replicated or multiplied in the mosquito's salivary glands and transmitted by bite to the next susceptible host bitten by the female mosquito. In Arizona, as in most of the Southwest, we are primarily concerned with four types of encephalitis, two of which are of major distribution in the state and two of which are of limited or unknown distribution in the state. Western Equine Encephalitis (WEE) and St. Louis Encephalitis (SLE) are the most common strains of the disease in Arizona and usually show up in human populations in the period from July through late

fall. The end of the encephalitis season for any one area corresponds to a couple of weeks or so after heavy frost.

In the case of human involvement, it is important to remember that the event in question, a mosquito bite that initiated the disease, occurred many days, even weeks, before the case was recognized and was possibly many miles away. The services of an epidemiologist, one who studies disease, are greatly needed to establish the pattern of the disease. The reader will note that in the names of the two mentioned diseases, Western Equine Encephalitis and St. Louis Encephalitis, the former includes the word "Equine" (referring to horse) while the latter does not. This is because WEE can also infect horses, showing typical neurological symptoms, not unlike those found in humans, while with SLE, even though the horse may become infected by the disease agent, it does not show symptoms. Thus, only with WEE may one expect to find horse cases preceding or occurring with human cases. Both of these disease strains are transmitted by Culex mosquitoes (Culex tarsalis, being the most accepted primary vector, followed in importance by Culex pipiens quinquefasciatus). All Culex breed in characteristic habitats.

The other types of mosquito-borne encephalitis that may occur in Arizona include Venezuelan Equine Encephalitis (VEE) and California Encephalitis (CE). Both of these viruses have been discovered in either surrounding states or in Mexico but thus far have limited or no known occurrence in Arizona. Unlike the two most important types of encephalitis, WEE and SLE, which have birds as natural reservoirs, VEE and CE arboviruses have mammalian hosts.

Other Arbovirus strains may become important to the state as research continues.

To summarize the vital details of arboviruses: 1) There is more than one type of arbovirus transmitted by mosquitoes, 2) The viruses are submicroscopic, and 3) Arboviruses need living vectors to transmit them. The epidemiology and control of arbovirus encephalitis are intimately tied to vector ecology.

2. MALARIA

Malaria is a disease caused by protozoons of the genus Plasmodium. It is transmitted from man to man by Anopheles mosquitoes. Although there is evidence that Malaria has been important in Arizona in its early history, and sporadically since then, the present potential for massive vector transmission in the state is questionable. Some counties in Arizona have vector capability in Anopheles freeborni, other counties have limited capability. For an outbreak there must be a human with an available pool of malaria parasites in the correct stage of development to be picked up by the mosquito. Most cases of Malaria in the state during the last decade have proven to be recurrent fever from past foreign infection, or recently arrived travellers in countries where malaria is still a critical health problem. Such patients are usually under stringent medication and their availability to vectors as hosts for malaria is limited. There has been proven "needle" transfer by drug users overseas.

It is good to point out that the first law of vector control is not to try 'outguessing vectors'. One must distinguish between

possibility and probability. Since Arizona has the vector and the susceptible population, the circle may be completed by introduction of an infected person carrying malaria, thus creating the possibility of malaria transmission in the state. Past experience, however, has indicated that the probability of this happening is somewhat limited.

III. CLASSIFICATION

As was learned from the 'core entomology text', mosquitoes belong to a taxonomic group known as Diptera, which includes house flies and black flies. Mosquitoes, however, belong to a Family within the Order Diptera known as the Culicidae. The Family Culicidae, in addition to the mosquitoes, contains two groups of midges closely resembling mosquitoes. Midges, like mosquitoes, have larval stages which are aquatic. Adult mosquitoes are distinguished from the other members of the family by their long, tubelike proboscis which is used in taking blood and other liquid food. Neither of the other midge-like representatives of the family have the proboscis since they do not take blood. All the mosquitos with which we are familiar fall into the Subfamily Culicinae. A key to the adult mosquitoes of New Mexico is included for your convenience. These keys will include most mosquitoes commonly found in Arizona and were kindly provided by the Center for Disease Control.

The rather fragile-looking adult has a long feeding tube or proboscis, scales on the wing veins and wing margin. Various combinations of colors and patterns of scales on the abdomen, thorax, and legs serve to identify the species. The larvae (see Keys to genus and species) are aquatic but breathe atmospheric air through a special

posterior breathing apparatus, known as an air tube. Between the larval and adult stages of development there is a pupa or resting stage. In the case of the mosquito pupa the resting refers to growth and food intake only, since it is quite active in its movements. The pupa, generally described as comma-shaped, actively moves through the water to escape predators and keeps its breathing apparatus available to the surface of the water. The spindle-shaped egg is deposited by the adult on the surface of the water, or in muddy margins singly or in clusters.

There is a further major subdivision of the mosquitoes. They are divided into either the Tribe Culicini which in Arizona includes the Aedes, Culex, Culiseta, Psorophora, and Orthopodomyia, or the Tribe Anophelini which in Arizona includes only the Genus Anopheles. The separation is based upon morphological and ecological differences described below.

In the Tribe Culicini, which includes all mosquitoes in Arizona except the Genus Anopheles, all the adults have their abdomen densely scaled and the palpi of the females are relatively short.

All the larvae in this tribe have a long dorsal siphon on the eighth abdominal segment. There is a large number, thirty (30) or more, of bristles or hairs comprising the mouth brushes.

The Tribe Anophelini contains both adults, that have palpi nearly as long as the proboscis, and larvae that lack a long dorsal siphon on the eighth abdominal segment.

In addition to the morphological differences, the Anopheles adult places her eggs singly on the surface of water. These single laid eggs have floats on their margins that distinguish them from all other Culicid eggs.

IV. LIFE CYCLE

The adult female mosquito, fertilized by the male, seeks out an aquatic situation in which to deposit her eggs. Genera differ sharply in their choice of location and in their mode of egg laying. Aedes and Psorophora mosquitoes, known commonly as "floodwater species" deposit eggs singly on the muddy margins of standing water. These eggs will not hatch until again inundated and, in fact, evidence indicates that they will not all hatch then, as some need repeated inundations. They are also capable of existing in dried mud for many years.

The eggs of Culex and Culiseta mosquitoes are deposited in groups (egg rafts) only on standing water, and the Anopheles lay eggs on water in several single egg units. Eggs deposited on the water surface are subject to quick hatching because of their susceptibility to predation and the limits on their floating ability. It is the Culex mosquito, in this latter group, that contains the primary vector species.

After hatching, the mosquito larvae now go through four instars, in which they shed the old skin (Ecdysis) and grow larger. With the exception of the function of larval breathing apparatus which requires Anopheles larvae to closely hug the surface of the water, most larval habits are quite similar. The larvae 'breed' in containers with a little water, water in tree cavities, and large, still bodies of water. It is at this stage of development that the mosquito is confined to a relatively well defined area, and is quite susceptible to aquatic predators, pesticides, and water management. The mosquito larva's needs at this stage are air and food. At this stage of development it is absolutely harmless to humans and, in fact, forms a portion of the aquatic food chain.

After the larval or 'wiggler' stage, the larvae encases itself

in a relatively impermeable pupal covering, and breathes through trumpet-like openings. Light detection is possible through the light sensitive eye areas. The comma-shaped pupa will readily dive if approached or disturbed in the water. This adaptation serves to protect the pupa during its relatively short period of transformation from the aquatic larval stage to the airborne adult stage. If an older pupa is dissected, most readily identifiable parts of the adult mosquito can be detected. During the pupal period the larval tissues are enzymatically reduced and reconstructed into adult tissues. During this stage the mosquito is less resistant to chemical control than in the larval or adult stages.

At emergence the pupal skin splits down the center, forming two symmetrical halves that form a floating pad upon which the mosquito may emerge, then pull its abdomen from the pupal case and rest until the wings are unfolded sufficiently to take flight.

The mosquito is now in its final form. The male mosquitoes generally emerge first and are relatively short-lived. The awaiting swarm rises to meet the newly emerged females. It is this swarm that often tips the vector man to an imminent emergence of mosquitoes. Within a few days of emergence the female mosquito now seeks a blood meal, necessary to complete the production of viable eggs. Alternatively both male and female mosquitoes may live on plant sap and nectar high in carbohydrates. The principal variances in adult habits lie in what species of animal or vertebrate the mosquito picks as its blood meal, the time of day it chooses to bite, and the distance it may reasonably be expected to migrate to obtain the blood.

Culiseta mosquitoes have a propensity for avian (bird) blood,

while many Aedes and Psorophora mosquitoes feast on blood of cattle, horses, and other large animals. Most mosquitoes have a wide range of hosts with certain known preferences. Culex mosquitoes feed on both birds and horses, as well as man, and this plays an important part in the vectoring of the arboviruses.

The mosquitoes with the longest known flight ranges are the Aedes and the Psorophora. Some of the species have a documented flight range of 10, 20, or 40 miles under certain circumstances. Culex and Anopheles mosquitoes are relatively short in their range. Regardless of wind and normal flight range, the principal determining reason for feeding is necessity. How far they must fly depends on how close the hosts are or what their host preferences are.

During the day Aedes and Psorophora mosquitoes dominate the field with their painful bites; toward dusk and evening the Culex and Anopheles mosquitoes tend to predominate. In dark, thick growth, with humidity, most biting activity increases. It can be seen that nocturnal exposure to mosquito bites, as opposed to strictly daytime activity, may play an important part in the spread of disease, since vectors species are most active at night.

Also, proximity of human population to mosquito breeding sources is elemental in the study of disease transmission. Because permanent water breeders such as Culex often follow 'floodwater' mosquitoes such as Aedes, water that stands without drying up or evaporating may cause a "pest" problem to turn into a 'disease' problem.

Understanding the dependence of a mosquito species upon ecological factors is vital to the conquest of disease that it carries.

V. SURVEILLANCE

Regardless of whether the mosquitoes are being controlled for disease or because of their pestiferousness, any proper control program is initiated with surveillance. Larval breeding sources are equally as important as the identification of adult populations, and may be more important from the standpoint of control.

A. LARVAL SURVEYS

Mosquitoes can be found breeding in just about any wet situation, including artificial containers (bottles, cans, tires, vases, urns, etc.), natural containers (tree holes, rock holes, etc.), grassy lake margins, marshes, slow streams, rain puddles, cow tracks and virtually any source of water that stays for longer than four or five days. Desirability of the water for mosquito breeding is enhanced by the presence of emergent vegetation, debris, protection from wind, lack of fish, shallowness, and other factors.

There are two advantages to the larval survey. The first is that larvae are found in a relatively confined area; therefore, the size of the control area in acreage is greatly reduced before they mature and disperse over a several mile radius. The second is that different larval sources can be associated with specific kinds of mosquitoes and a large number of species can be eliminated from consideration based on the breeding site.

For years the standard equipment for larval surveys has been the kitchen drinking dipper, usually attached to a three or four foot dowel. The breeding site is quantitated by comparing number of mosquito larvae 'per dip'. This notation gives other vector control personnel a comparison figure for larval density. Mosquito

larvae can be individually picked from the contents of the dipper with a bulb type pipette and transferred to a vial. For more permanent preservation, since they will readily die in the container, most of the water is removed by the pipette and some preservative such as isopropyl alcohol, or ethyl alcohol is added. A superior fixative is the material ethylene glycol, monoethyl ether, sometimes called 'Cellosolve'. It is a solvent available from chemical supply houses. Addition of 1% glycerene to alcohol will help keep the tissues soft for future manipulation. The usual storage percentage for these preservatives is 70 percent.

Mosquitoes, breeding in tree holes, roof gutters, or rock holes, may be recovered by use of the bulb pipette since dippers are usually too cumbersome in the confined places. Tin cans, bottles, and other artificial containers may be inverted into the dipper when inspecting these places. Mosquito pupae are collected along with the larvae. Since pupal taxonomy is difficult, it is wise to separate the pupae into a larger container, cover it with netting and allow the mosquitoes to emerge into the more identifiable adult stage.

To standardize the technique of dipping and to allow for more efficient survey, it is instructional to render some advice to those persons initiating their first larval survey. When approaching a suspected breeding site, the investigator should avoid disturbing the water, even by casting a shadow over it. A disturbance of any type will immediately send all larvae and pupae to the bottom of the pool and will make evaluation difficult. Casual

observation before dipping will usually reveal a source of larvae clustered around protected margins of the pool, or balled up near vegetation. Anopheles larvae float like small sticks parallel to the surface of the water. A skimming motion will capture the most larvae. When a lot of debris or vegetation is present the dipper is carefully submerged, allowing the inflow to suck in larvae from nearby vegetation.

B. ADULT SURVEILLANCE

Adult surveys enable vector control personnel to evaluate the true incidence as well as the species of mosquitoes that are present in an area. It is known that complaints delivered by the public are often flavored with some bias. The arrival of a complaint should trigger a follow-up to determine the actual need for control measures. If, in fact, larval source reduction is an integral part of the control program, the complaint can be a valuable resource.

1. LIGHT TRAPPING

Many mosquito species in the United States are attracted to light. Light traps are basically of two types: those which are relatively stationary, designed for long term operation, and operated by household current; and those which are temporary survey traps, extremely portable, but limited by battery operation. Either operates on the principle that mosquitoes attracted to a light are captured and propelled into a collecting device by a fan-induced suction. At this point the mosquitoes are either killed by insecticidal devices or carefully kept alive for virus determination or other purposes.

With either device it is important to suspend the lamp high enough, ideally about six feet, with a minimum distance of thirty (30) feet or more from buildings, trees and shrubs which will diminish the attraction from the light. Strong competitive lights such as street lights and floodlights should be avoided as well as areas with strong vapors and smokes.

2. BITING COUNTS

Landing or biting counts utilize the natural attractiveness of the investigator to biting insects. It is perhaps the most useful since it samples only those mosquitoes that are attracted to humans. The sampler stands quietly for ten or fifteen minutes and counts the mosquitoes that land on his skin and clothing. Sometimes landing counts are taken using two investigators who count the landings on each other. This latter arrangement makes it more efficient when the mosquitoes are to be captured.

Capture of landing mosquitoes is best accomplished by the tube aspirator. Basically this instrument consists of a glass tube attached to a flexible hose with a piece of gauze or cotton made to stopper it at the junction of the two. Gentle suction on the hose is sufficient to pull mosquitoes down the glass tube to the gauze plug. The insect can then be blown into a killing tube or jar for preservation and identification.

3. RESTING STATIONS

The adults of many mosquito species, especially night biters, may pick quiet resting spots during the day, such as culverts, hollow trees, caves, etc. Overwintering adults also

choose such sites. Sampling these sites with the tube aspirator described above will give an idea of the species involved. Where insufficient natural sources exist, artifical shelters may be manufactured in the form of temporary sheds, boxes, barrels, or the like. By limiting access into the container with a conical, inward pointing screen, and adding bait such as a small animal, or dry ice (CO_2), the resting station becomes a very efficient bait station. Vector species are easily captured with this kind of device. Many such bait stations may be distributed over the area and serviced by a single individual.

C. EGG SAMPLING

In dry areas with undependable rainfall, floodwater species may be sampled by cutting dry sod and immersing it in unchlorinated water. The larvae will usually hatch with such a technique, although seldom with the efficiency they do in nature. Elaborate machines have been developed to separate the actual eggs from the sod, but these are not recommended for other than research purposes.

VI. RECORDS AND RECORD KEEPING

All of the above is to no avail unless the results are recorded and arranged in such a fashion that the information is usable. Breeding sites should be spotted on a map by numbers, and an index should describe the species found there and the type of habitat. Light trap records should be accumulated and the adult species and number plotted on a graph for future use as a prognostic device. Although each season varies a little due to fluctuating climatic conditions, both of the above records will greatly assist the vector control effort over a period of years. Additionally, in the event of an arbovirus outbreak, such records will

greatly diminish the unnecessary "shotgun" spraying that is often undertaken during the panic of the outbreak.

VII. CONTROL

No attempt will be made in this manual to identify specific materials and rates of application, since they are subject to frequent change. Instead, the techniques of control will be discussed.

A. INTEGRATED CONTROL

The principle of control of mosquitoes does not involve any one method, be it chemical, biological, or water management, but a combination of factors harmonious with each other, tuned to the particular situation and compatible with each other and the environment. Larval source reduction involves one of our most fragile commodities, surface water. Special care must be undertaken in effecting such control.

B. BIOLOGICAL CONTROL

Biological control of mosquitoes is the oldest but one of the least researched of all control methods. Birds such as the purple martin, insect predators like dragon flies, fish such as the top minnow, and even microorganisms like *Bacillus thuringiensis* have been variously hailed as the ultimate mosquito control weapon. All biological controls thus far tested have limitations. The only strictly biological measure of consequence in Arizona is the use of fish, principally of the top feeding type and limited largely to the mosquito fish *Gambusia affinis* and the Gila topminnow, *Poeciliopsis spp*. Even within this biological control group there lies a difficulty. The *Gambusia* species is much more vigorous in its habitat

than the native Gila topminnow and overcompetes to the point that the latter species is crowded out. Since Poeciliopsis spp. is a threatened native, it is on the "endangered species" list and as such will carry the full protection afforded it by the 'Endangered Species Act of 1973'. The operational effect of this is that, even now, waters bearing native Gila topminnows should not be seeded with Gambusia affinis in the State of Arizona. To determine which waters are known to harbor this native fish it is best to check with the non-game fisheries specialist of the Arizona Department of Game and Fish. Basically, Gambusia affinis and, to a somewhat lesser extent, Poeciliopsis are very efficient larvavores and where the breeding site does not dry up and where vegetation does not limit their penetrability, they are the only control that is required.

C. WATER MANAGEMENT

The basis of water management for mosquito control is either to remove the water (source reduction) or to modify it so that it is no longer suitable for production. Removal of water by drainage is ideal for unimportant temporary rainpools and in drying up irrigation spillages, but drying up of natural water accumulations such as marshes, swamps, and shallow lakes is met with increasing hostility by environmental groups.

Remember that there are certain conditions that promote mosquito breeding. These include emergent vegetation, shallow water, lack of wind action, organic debris, and exclusion of fish. Careful study and manipulation of these factors along with introduction of fish has enabled many mosquito breeding sites to be

effectively altered to the mutual benefit of both wildlife and mosquito control concerns. Ditches to allow natural fish access to remote pools may replace drainage of these sites. Water level adjustment to control emergent vegetation types has greatly reduced mosquito breeding in certain cases while promoting even better vegetation for shore dwelling wildlife. The possibilities are virtually unlimited for water management. Inherent to the water management of mosquito pests there are two major difficulties: 1) This method often involves the use of major pieces of equipment and elaborate planning for alteration of extensive surface water conditions. 2) Traditionally, there has been a lack of productive communication between wildlife interests and mosquito control personnel. Fortunately, the latter barrier is slowly giving way before the efforts of research and integrated interest groups but much more public relations effort is needed in this field.

D. CHEMICAL CONTROL

Chemical control of mosquitoes should be designed so that major emphasis is placed on the larval sources. By simple mathematics it can be seen that the amount of acreage that breeds mosquitoes is a mere fraction of that over which adults will disperse. From the standpoint of cost as well as the environment, larval breeding sites should be considered carefully for pesticide treatment.

Chemical control of larvae can be accomplished with special oils applied thinly over the surface of the water by spreader additives. These simple pesticides enter the air tubes of the

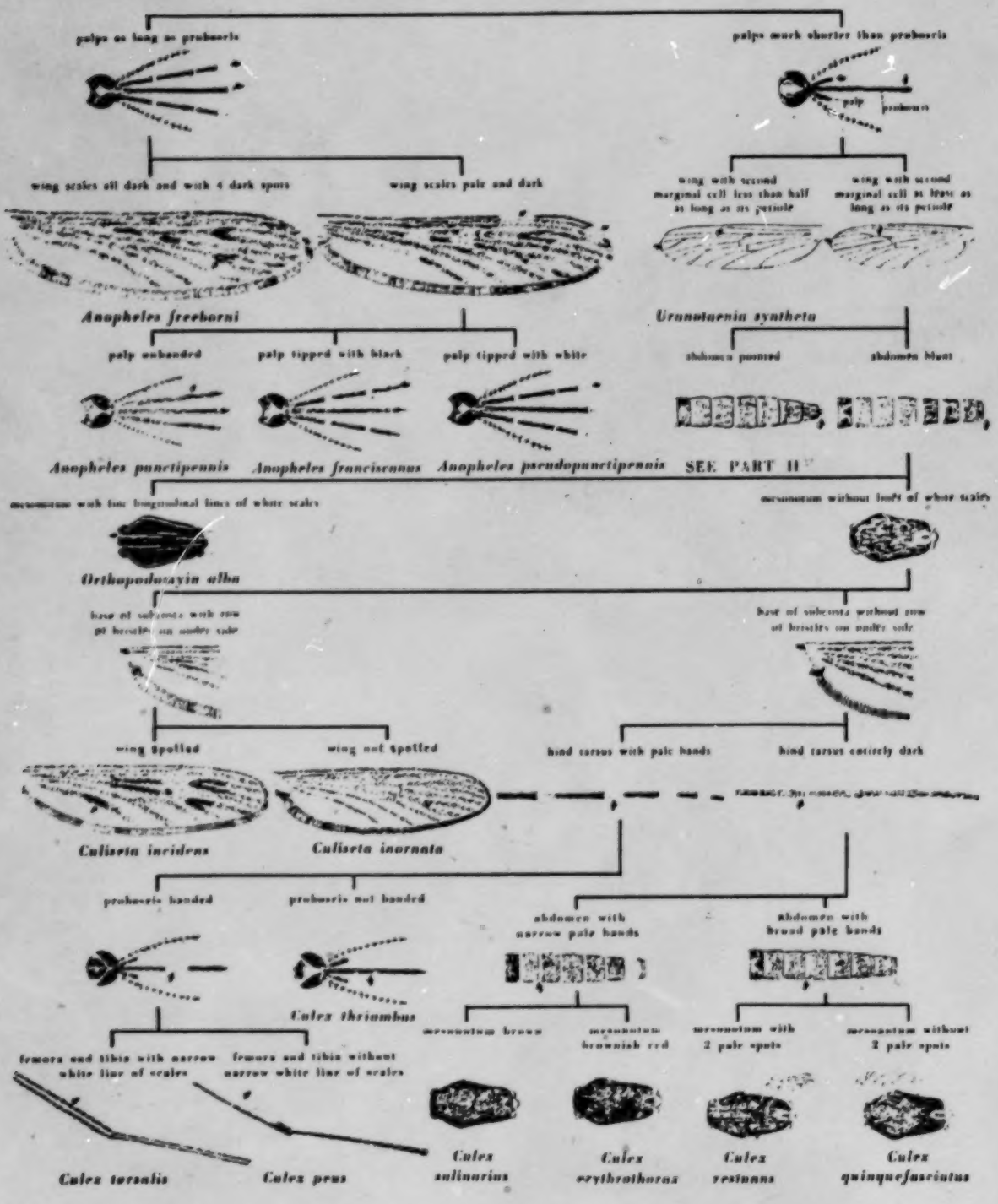
mosquito larvae and both suffocate and poison the insect. Where more stringent methods are needed, pesticides may be added to the oil, or water soluble formulations may be applied at label recommendations to kill the larvae by contact and ingestion. One important difference occurs between the oil and water soluble formulations. In the latter, volume of the habitat becomes much more critical and, consequently, there is often a need to increase the actual amount of pesticide applied per acre, since dosage rate depends upon volumetric rather than surface area proportions. The average depth of water is necessary to calculate volume, and is a difficult thing to determine in many instances.

Adult control depends largely upon the application of aerosol insecticide formulations over large areas of the environment. This is likely to be admixed into human population centers and will require repeated applications, since invasion from untreated peripheral areas will most surely occur.

Depending upon the size of the aerosol generated (from a spray to a dry fog), drift becomes an increasing problem, as does inversion of the pesticide droplet.

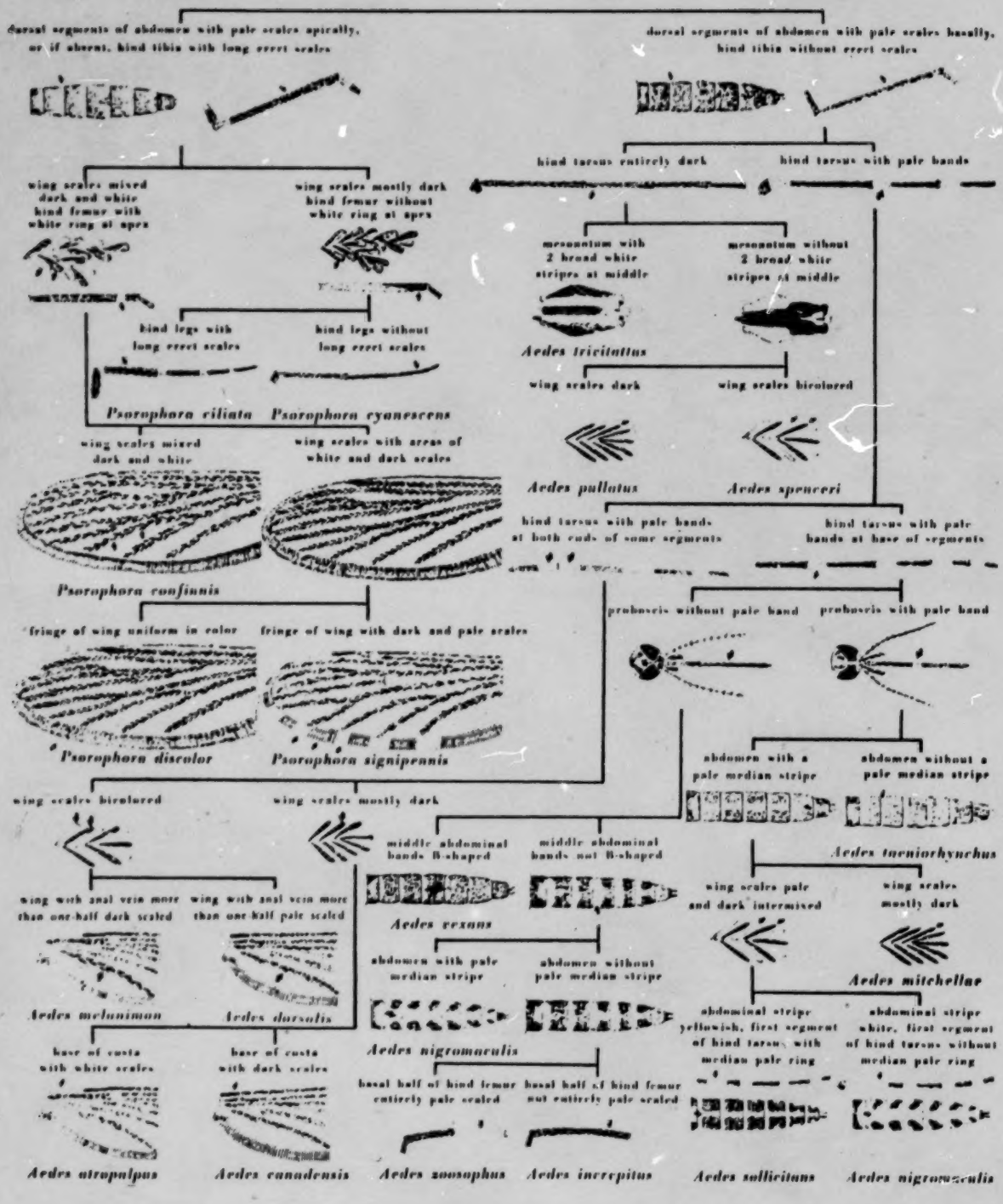
MOSQUITOES: PICTORIAL KEY TO MOST ADULTS (FEMALE) OF NEW MEXICO
PART I

Chester J. Stojanovich


palps as long as proboscis
palps much shorter than proboscis
palp
proboscis
wing scales all dark and with 4 dark spots
wing scales pale and dark
wing with second marginal cell less than half as long as its petiole
wing with second marginal cell at least as long as its petiole
Anopheles freeborni
Uranotaenia sapphirina
palp unbanded
palp tipped with black
palp tipped with white
abdomen pointed
abdomen blunt
Anopheles punctipennis
Anopheles franciscanus
Anopheles pseudopunctipennis
SEE PART II
mesonotum with fine longitudinal lines of white scales
mesonotum without lines of white scales
Orthopodomyia alba
base of subcosta with row of bristles on under side
base of subcosta without row of bristles on under side
wing spotted
wing not spotted
hind tarsus with pale bands
hind tarsus entirely dark
Culiseta inidens
Culiseta inornata
proboscis banded
proboscis not banded
abdomen with narrow pale bands
abdomen with broad pale bands
Culex thriambus
mesonotum brown
mesonotum brownish red
mesonotum with 2 pale spots
mesonotum without 2 pale spots
femora and tibia with narrow white line of scales
femora and tibia without narrow white line of scales
Culex tarsalis
Culex pres
Culex salinarius
Culex erythrothorax
Culex restuans
Culex quinquefasciatus

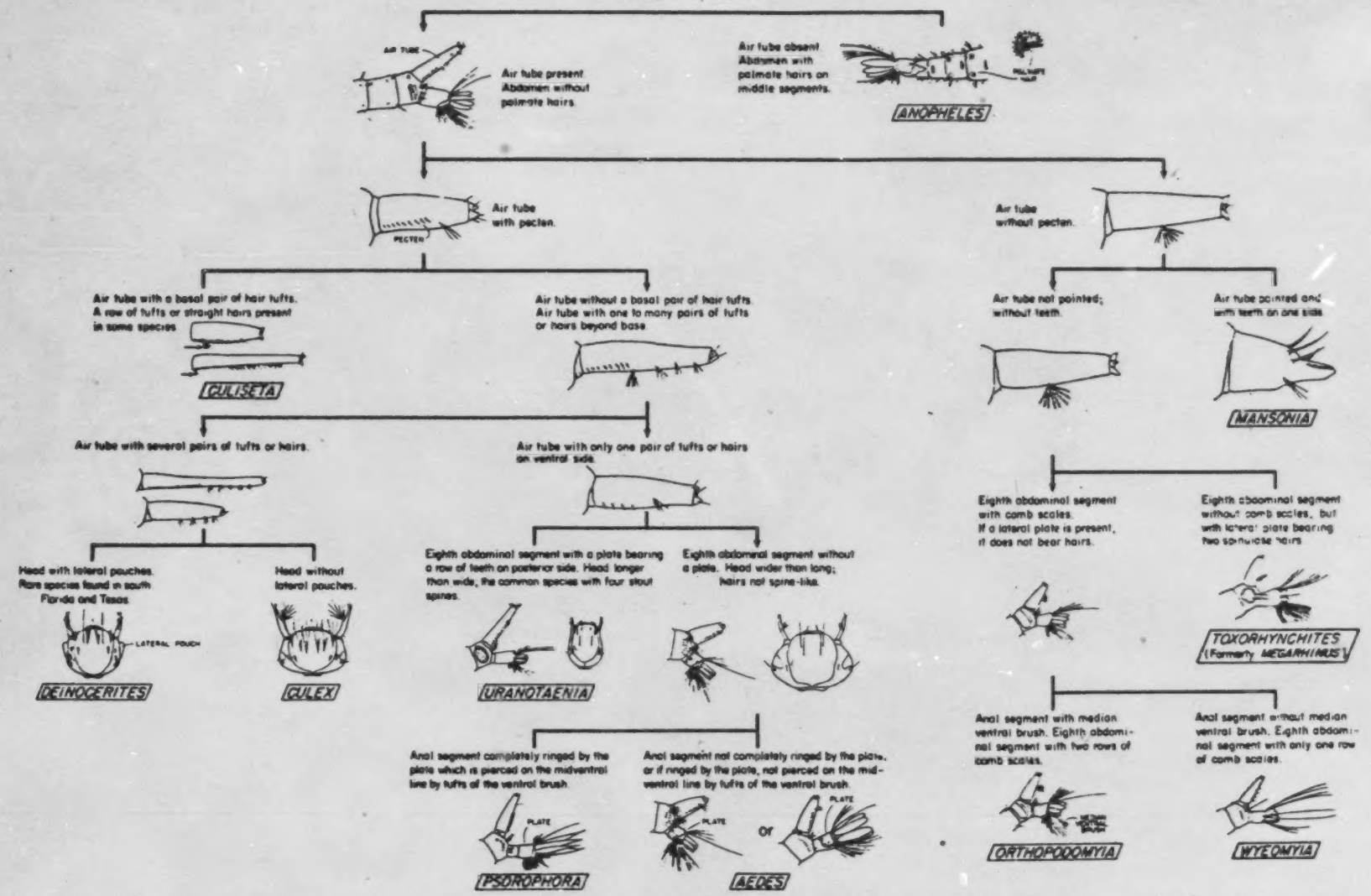
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1964

PART II


dorsal segments of abdomen with pale scales apically, or if absent, hind tibia with long erect scales
dorsal segments of abdomen with pale scales basally, hind tibia without erect scales
wing scales mixed dark and white hind femur with white ring at apex
wing scales mostly dark hind femur without white ring at apex
hind legs with long erect scales
hind legs without long erect scales
Psorophora ciliata
Psorophora cyanescens
wing scales mixed dark and white
wing scales with areas of white and dark scales
Psorophora confinnis
fringe of wing uniform in color
fringe of wing with dark and pale scales
Psorophora discolor
Psorophora signipennis
wing scales bicolored
wing scales mostly dark
wing with anal vein more than one-half dark scaled
wing with anal vein more than one-half pale scaled
Aedes melanimon
Aedes dorsalis
base of costa with white scales
base of costa with dark scales
Aedes atropalpus
Aedes canadensis
hind tarsus entirely dark
hind tarsus with pale bands
mesonotum with 2 broad white stripes at middle
mesonotum without 2 broad white stripes at middle
Aedes tricitatus
wing scales dark
wing scales bicolored
Aedes pullatus
Aedes spencerii
hind tarsus with pale bands at both ends of some segments
hind tarsus with pale bands at base of segments
proboscis without pale band
proboscis with pale band
middle abdominal bands B-shaped
middle abdominal bands not B-shaped
Aedes vexans
abdomen with pale median stripe
abdomen without pale median stripe
Aedes nigromaculis
basal half of hind femur entirely pale scaled
basal half of hind femur not entirely pale scaled
Aedes zoosophus
Aedes increpitus
abdomen with a pale median stripe
abdomen without a pale median stripe
Aedes taeniorhynchus
wing scales pale and dark intermixed
wing scales mostly dark
Aedes mitchellae
abdominal stripe yellowish, first segment of hind tarsus with median pale ring
abdominal stripe white, first segment of hind tarsus without median pale ring
Aedes sollicitans
Aedes nigromaculis

MOSQUITOES: PICTORIAL KEY TO U.S. GENERA OF LARVAE

Harry D. Pratt


AIR TUBE
Air tube present. Abdomen without palmate hairs.
Air tube absent. Abdomen with palmate hairs on middle segments.
ANOPHELES
PECTEN
Air tube with pecten.
Air tube without pecten.
Air tube with a basal pair of hair tufts. A row of tufts or straight hairs present in some species
CULISETA
Air tube without a basal pair of hair tufts. Air tube with one to many pairs of tufts or hairs beyond base
Air tube not pointed; without teeth.
Air tube pointed and with teeth on one side
MANSONIA
Air tube with several pairs of tufts or hairs.
Air tube with only one pair of tufts or hairs on ventral side.
Eighth abdominal segment with comb scales. If a lateral plate is present, it does not bear hairs.
Eighth abdominal segment without comb scales, but with lateral plate bearing two spinulose hairs
Head with lateral pouches. Rare species found in south Florida and Texas
LATERAL POUCH
DELNOCERITES
Head without lateral pouches.
CULEX
Eighth abdominal segment with a plate bearing a row of teeth on posterior side. Head longer than wide, the common species with four stout spines.
Eighth abdominal segment without a plate. Head wider than long; hairs not spine-like.
URANOTAENIA
TOXORHYNCHITES (Formerly MEGARHINUS)
Anal segment completely ringed by the plate which is pierced on the midventral line by tufts of the ventral brush.
Anal segment not completely ringed by the plate, or if ringed by the plate, not pierced on the midventral line by tufts of the ventral brush.
PLATE
PSOROPHORA
or
AEDES
Anal segment with median ventral brush. Eighth abdominal segment with two rows of comb scales.
Anal segment without median ventral brush. Eighth abdominal segment with only one row of comb scales.
ORTHOPODOMYIA
WYEOMYIA

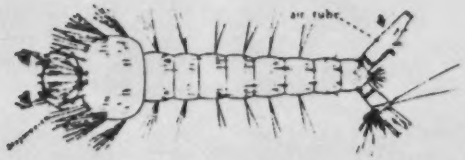
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1959

1-21

MOSQUITOES: PICTORIAL KEY TO SOME COMMON LARVAE OF WESTERN UNITED STATES

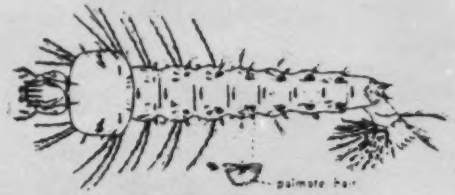
Harry D. Pratt

Air tube present at tip of abdomen; palmate hairs absent on middle abdominal segments



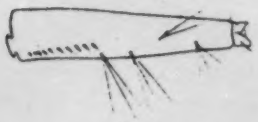
CULICINE MOSQUITOES

Air tube absent at tip of abdomen; palmate hairs present on middle abdominal segments

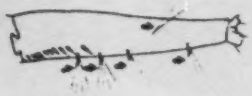


WESTERN MALARIAL MOSQUITO
Anopheles freeborni

Air tube with several tufts on each side
GENUS *Culex*



Air tube with 5 or more tufts on each side



Air tube with 4 tufts on each side

HOUSE MOSQUITO
Culex pipiens

All tufts on each side inserted in a straight line.

ENCEPHALITIS MOSQUITO
Culex tarsalis

One or more tufts on each side out of line.

Culex pres

Air tube with a tuft at base on each side
GENUS *Culiseta*

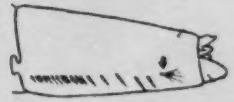
Lateral hair of anal segment as long as, or longer than, anal segment; stout

Culiseta inornata

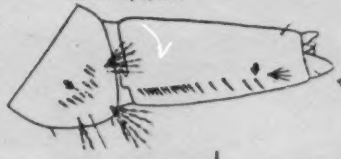
Lateral hair of anal segment shorter than anal segment; fine

Culiseta incidens

Air tube with a tuft beyond base on each side.
GENUS *Aedes*

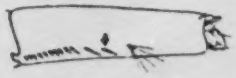


5–14 comb scales on 8th abdominal segment; last tooth of pecten on air tube widely spaced.



20–50 comb scales on 8th abdominal segment; last tooth of pecten on air evenly spaced

Pecten teeth extend to about middle of air tube



Aedes vexans

Pecten teeth extend much beyond middle of air tube

Aedes nigromaculis

Anal gills shorter than anal segment

Aedes dorsalis

Anal gills longer than anal segment

Aedes sticticus

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1960

FLIES

I. INTRODUCTION

Flies are insects belonging to the taxonomic Order Diptera. As the name implies, there are two wings, one pair. There are, in addition, rudiments of a second pair of wings that manifest themselves as knob-like structures called halteres positioned behind the wings. There are many different species of flies recorded in entomological literature, but only a fraction of these are important to vector control in Arizona.

In the present chapter the author will exclude the most noteworthy member of the Order Diptera, the Mosquitoes, and devote an entire chapter to them alone.

II. PUBLIC HEALTH IMPORTANCE

A. DISEASE (FILTH FLIES)

There is little doubt that the hairy body surfaces, vomitus, and feces of 'filth' flies harbor pathogenic bacteria. They are considered mechanical transmitters of disease to distinguish them from the type of transmission where the pathogen may undergo a developmental change in the vector, such as in malaria and the encephalitides. The vomitus of the fly is regurgitated over soluble food and is then reingested with the dissolved food. Filth flies indiscriminately land on and wander through filth, feces, food, open sores, and moist body openings. Disease causing microorganisms associated with filth flies include amoebic and bacillary dysentery, typhoid fever, cholera, salmonella, anthrax, leprosy, yaws, trachoma, poliomyelitis, infectious hepatitis, conjunctivitis and eggs of pinworms, whipworms, hookworms, ascarids and tapeworms. Although it is difficult to trace

a house fly as the mechanical vector for a specific outbreak of disease amongst a human population, experimental evidence indicates that flies are vectors and can transmit pathogenic microorganisms which contribute to disease spread in a given area.

B. BITING

Major biting flies other than mosquitoes are the stable fly, black fly, deer fly and punkie or biting midge. The black fly, which has not been implicated in disease transmission in this country, is extremely bothersome to Bullhead City dwellers on the Colorado River. It bites some persons and even when not biting continually swarms around the head. Horse and deer flies and biting midges are sporadically bothersome in parts of the State. The biting midge is occasionally found in desert areas where it breeds in rot cavities in the saguaro cactus. Stable flies can be very bothersome around cattle pens or horse stalls during certain seasons. Of the biting flies, other than mosquitoes, most are not considered important in disease transmission, but their activity is acutely annoying and has some economic importance in discouraging tourism, fishing, and business.

C. MYIASIS

The invasion of the body of man or animals by the larvae of a fly is known as myiasis. There have been some spectacular medical cases of myiasis in humans and animals which are more or less medical classics but their frequency is erratic. The most noted myiasis in the state involves the screwworm, the object of a massive control program by the United States Department of Agriculture. This fly is important in the livestock industry but the incidence in humans is rare.

III. IDENTIFICATION

A minor difference in the external features of a fly may translate into a significant difference in the biology and control of the fly, so that it is worth spending some time on the identification of these insects. The general characteristics that are the most valuable in adult fly identification are size, shape, markings on the wings and thorax and in some cases color. (See accompanying chart on domestic flies, especially the lower left corner diagram.) Larval identification often depends upon size, shape and spiracular pattern or arrangement. The reader is referred to the excellent keys developed by the Center for Disease Control.

IV. LIFE CYCLES AND GENERAL CHARACTERISTICS

When speaking of common characteristics, the only thing that can be said with certainty is that flies undergo a complete metamorphosis in their life cycle. The egg, larva (maggot), pupa, and adult do not resemble one another, and in many cases differ dramatically between the species. Lengths of the stages are dependent upon temperature, humidity, quality and quantity of food and geographical area so that these parameters must be spoken of in general time allotments that may vary locally. The vector control worker becomes the expert in his locality.

A. EGGS

The general rule for flies is that they produce and lay eggs, although some species, such as members of the flesh fly (Sarcophagidae) family retain the eggs until hatched and give birth to larvae. Breeding media varies greatly within the species but usually consists of organic matter in some stage of decay. Some species, other than mosquitoes, lay eggs in aquatic situations, even running water (blackflies).

B. LARVAE

The larval stage of nuisance flies breed either in quite moist, decaying, organic matter, then migrate out to a drier media toward the end of the larval development, or stay in water throughout their larval and pupal development. Characteristically, either type larvae has mouth hooks or some sort of tearing appendage on its front and a breathing apparatus on the rear. Fly larvae are legless, more or less cylindrical, and are usually tapered at one end. (See Chart.) At this stage a search through the breeding media is generally required to detect the larvae.

C. PUPAE

The pupal stage is semi-protective. The larvae or its remains is generally covered with a harder covering to form the pupae. The shape of the pupa sometimes follows that of the larvae (Fannia) but often becomes more shapeless, generally round or oval, dark brown in color and the size is indicative of the larval size. Flies have developed an interesting escape mechanism from the pupal stage and the adult often utilizes a protrusible bladder-like sac on the top of its head to rupture the pupal case. The emerged fly is usually pale, with wings greatly shriveled and often lacks the color and shape of its species until the exoskeleton is sufficiently hardened.

D. ADULTS

Most filth inhabiting flies have spongy mouthparts which depend on external solubilization of the source prior to ingestion, the source of so-called "vomitus" spots. Other nuisance flies, such as stable, deer and horse flies, and blackflies have mouth parts which enable them to either penetrate and suck, cut or slash,

then lap up the blood of victims. Specific life cycles are summarized in the chart.

V. SURVEILLANCE

Surveillance of the fly population may be accomplished in different ways for specific purposes.

A. DIRECT OBSERVATION

This approach is the most suited to non-routine, poorly equipped, or occasional complaint situations, but still requires considerable knowledge and skill in their interpretation. The results obtained must be used with great care since observations are apt to be very subjective. Where control or correction of the situation has been undertaken, the same investigator should be sent in both instances. The investigator must also inspect likely breeding sites, taking care to observe any potential site in the area. The observation of adult activity alone seldom presents a true picture of the situation. Samples of both larvae and adults should be collected for reference at the same time the observation is being made. Larvae taken can be temporarily carried in almost any container or stoppered vial. Adult flies can be taken even without the advantage of a sweep net by placing a clear glass container over them at rest, then slipping a rigid paper or cardboard under the mouth of the container. Thus contained the fly can be immobilized with tobacco smoke, the sun's heat, or simply brought in entrapped and secured in the container. Entomological help on the problem is greatly aided by supplying undamaged specimens.

B. FLY TRAPS

The most common fly trap used in surveys is the cone trap.

This trap uses an inverted cone made of window screen placed two or three inches above a plate filled with suitable bait. The flies are attracted to the bait and, after feeding, fly upward through the narrow end into a small container.

C. FLY GRILL

The Scudder fly grill is a fairly reliable fly population index. It consists of a 24" by 24" frame of wood covered with 3/4" slats aligned in parallel to present multiple resting edges. It is placed over naturally occurring attractants and a 30 second landing count is made. A minimum of ten such counts must be made in the area and averaged. If comparison counts are desirable the grill must be placed exactly the same on return visits. Where the fly population is too great, a half or quarter of the grid may be counted.

D. FLY PAPER COUNTS

Commercial fly paper strips have been used to collect for a few hours in a specified site. The flies may then be retained for identification. Many flies will not come to the strips, however, and the technique is used primarily for housefly surveys.

VI. EQUIPMENT

With any of the above surveys it is well to reinforce the technique with some simple equipment. Typical equipment involved should include insect sweep net, a small trowel, tongue depressors and a supply of glass vials, a preservative such as cellosolve (ethylene glycol monoethyl ether) and a small killing jar made from a stoppered jar. The killing agent is portions of DDVP resin strip in plaster of paris.

VII. CONTROL

The control of flies presents a unique historical development in vector control activities. During the horse and buggy days, flies were so numerous and control so futile that they were simply tolerated. As the relationship of flies, at least statistically, to dysentery, infantile diarrhea, and polio became suspected, homes were screened, and other methods such as spraying were developed to reduce numbers of flies. Along with the development of DDT and other pesticides, entomological recommendations began to take effect in the elimination of pit privies and increased efforts at refuse collection and disposal. The control of filth breeding flies began to be taken for granted by most people. While the public clamor subsided and interest waned, the flies began to develop resistance to one after the other of the pesticides. Long before the Environmental Protection Agency began to invoke technical sanctions against the use of pesticides alone for fly control, public health departments were stressing environmental sanitation methods as a partial or complete substitute for chemical control. The public had become accustomed to the easy way of chemical control. Major emphasis was directed toward chemical control of flies in dairies, feed lots and poultry farms. Fly breeding associated with common household garbage, domestic animal droppings and other less identifiable fly breeding sources were largely ignored.

A. ENVIRONMENTAL SANITATION

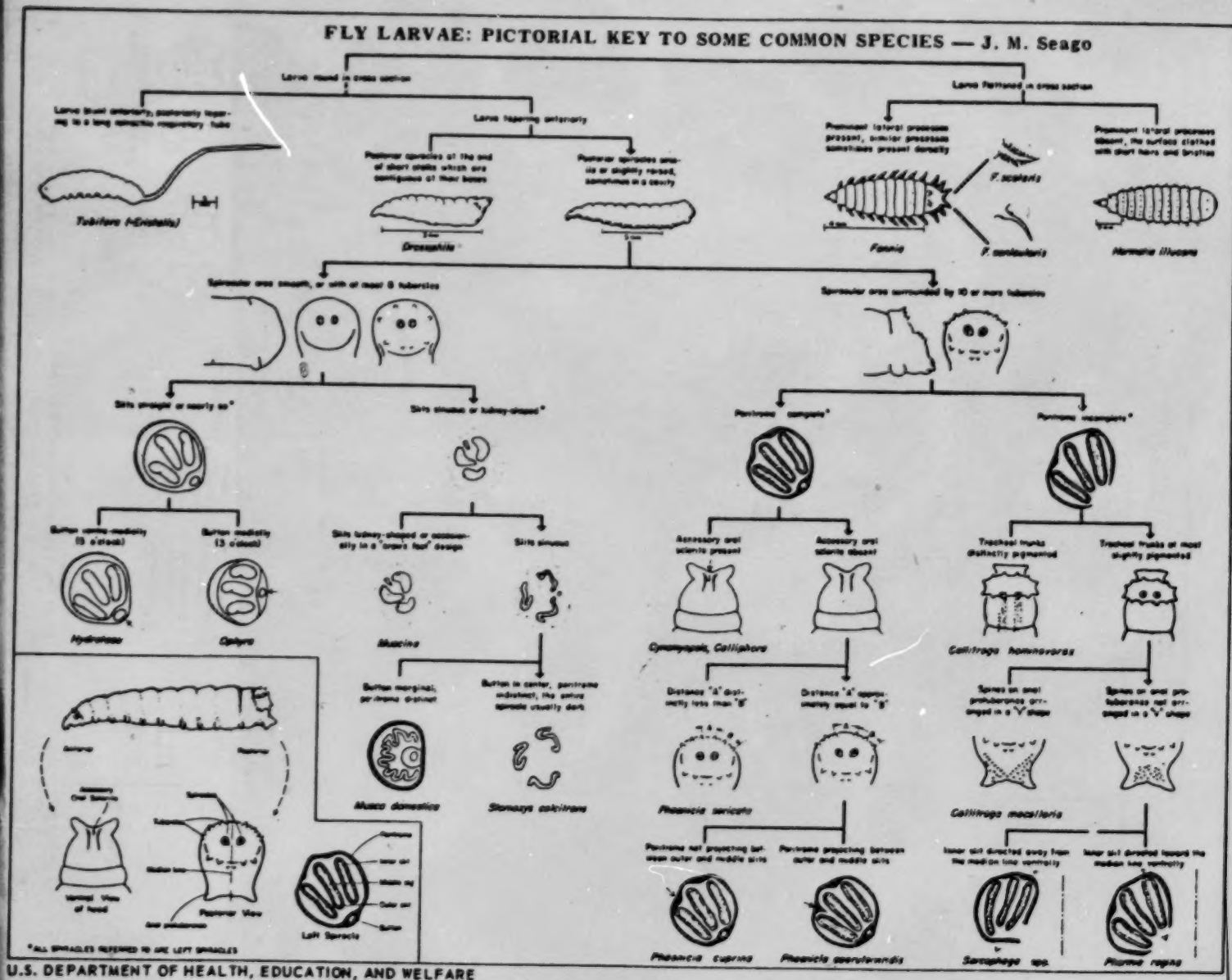
Refuse, the waste of modern living, has replaced animal manure as the chief source of domestic flies. Sanitary storage, twice weekly collection and proper covering, compaction and landfill maintenance are needed to reduce the household and commercial refuse

problem. Animal feeds, excrement and other minor and varied fly breeding sources, which sometimes require imaginative investigation, need to be sought and eliminated on a routine basis. Environmental control of non-domestic flies can require diverse and extremely variable methods, some of which are outlined in the accompanying chart (ENVIRONMENTAL CONTROL OF NON-DOMESTIC FLIES).

B. CHEMICAL CONTROL

Where larval sources cannot be removed or prevented, it may be necessary to larvicide the material. Since this type of situation is often under or adjacent to livestock such as chickens, cattle, etc., extreme care must be taken to avoid contamination of the food, water, or livestock. Seldom will chemical control of the larva be effective without some further environmental sanitation effort.

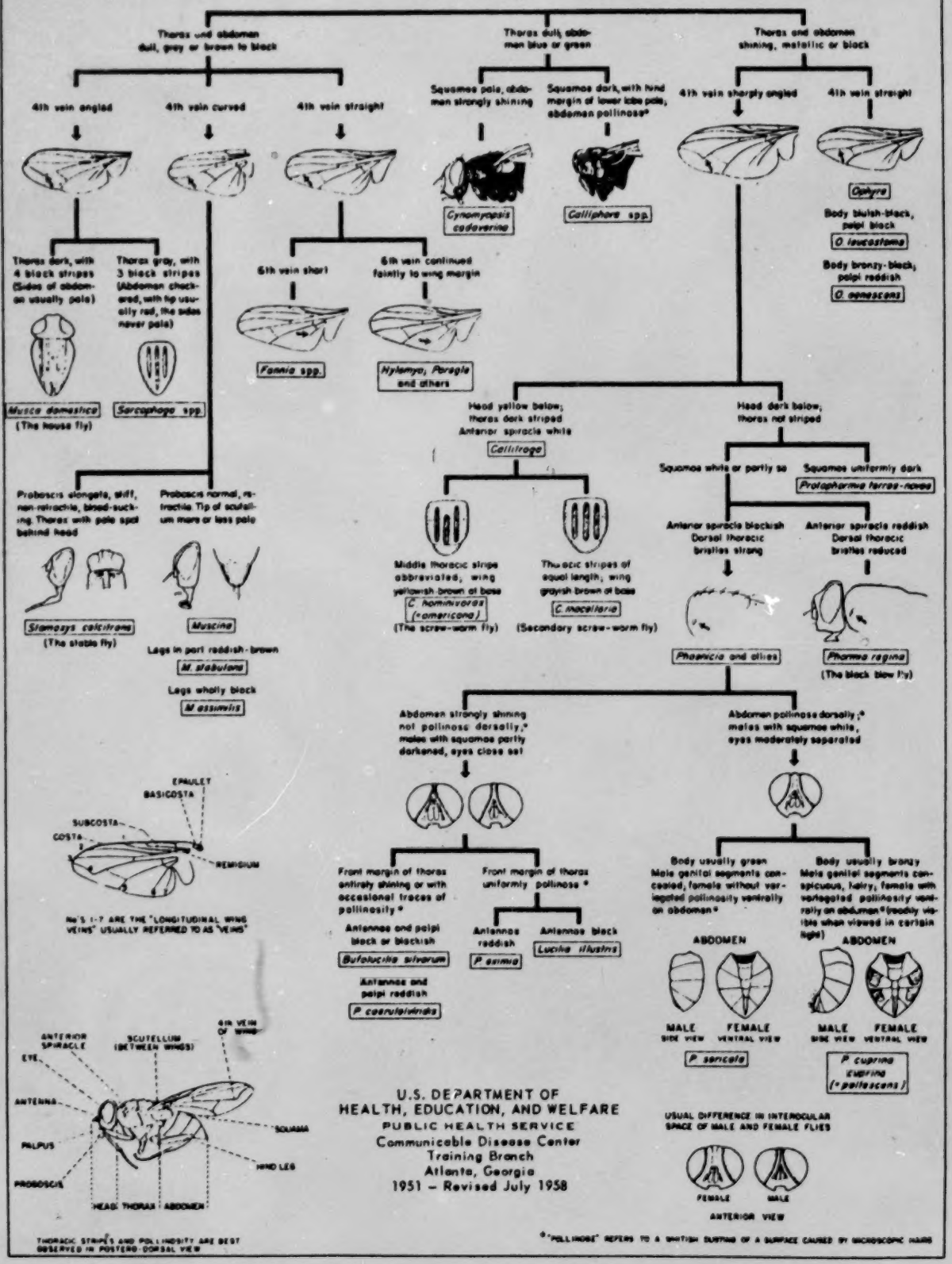
Adult control may be accomplished by space spraying with misting machines or fog generators (refer to application equipment chapter). Additionally, there are sugar bait mixtures and residual applications available on the market. The labeling and availability of these materials is so subject to change that it is impractical to list them herein.



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1952 – Revised 1953.

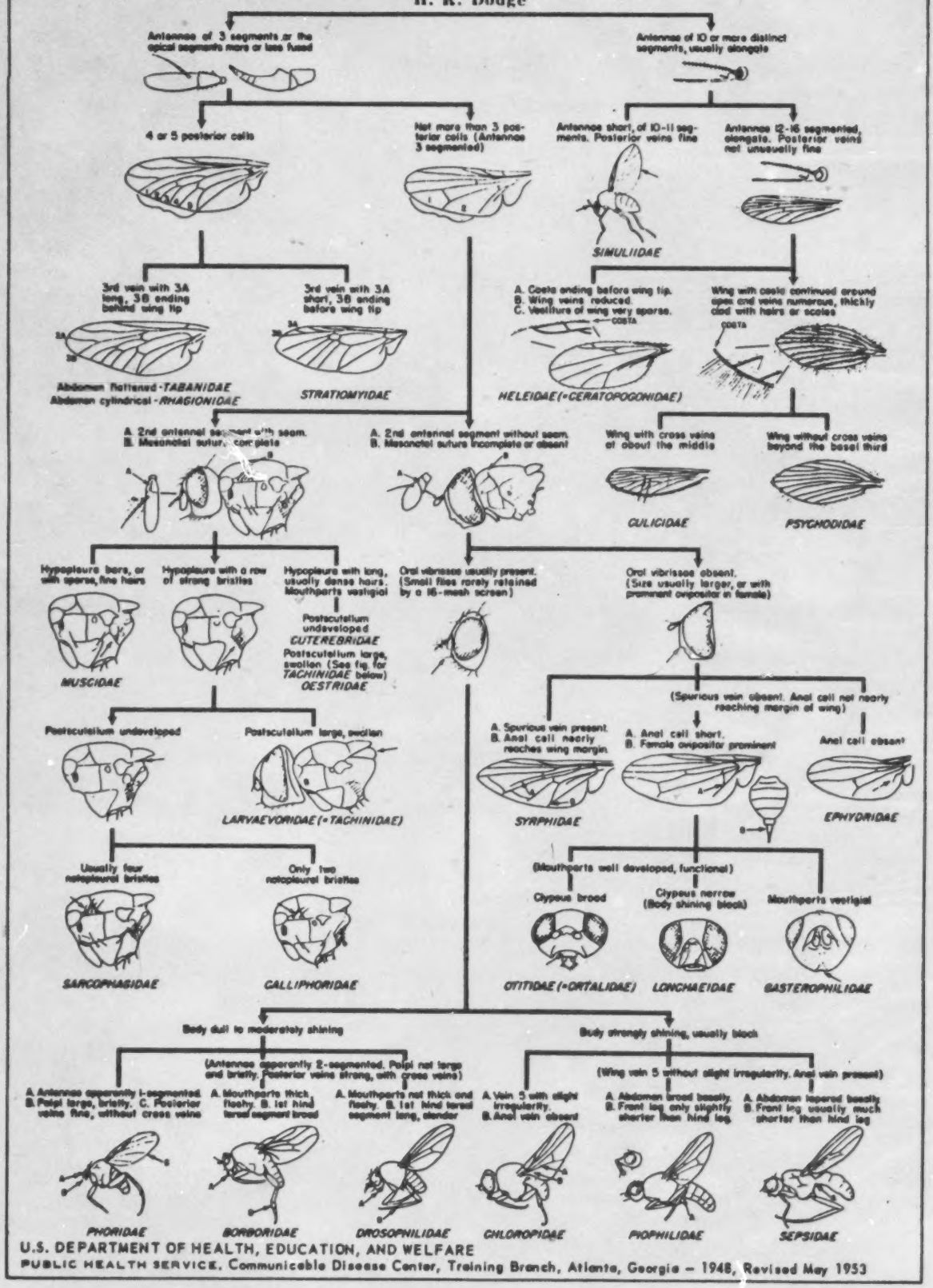
DOMESTIC FLIES: PICTORIAL KEY TO COMMON SPECIES IN THE U.S.

H. R. Dodge


Thorax and abdomen dull, gray or brown to black
Thorax dull, abdomen blue or green
Thorax and abdomen shining, metallic or black
4th vein angled
4th vein curved
4th vein straight
Squamae pale, abdomen strongly shining
Squamae dark, with hind margin of lower lobe pale, abdomen pollinose*
4th vein sharply angled
4th vein straight
Cynomopsis cadaverina
Calliphora spp.
Ophyra
Body bluish-black, palpi black
O. leucostoma
Body bronzy-black, palpi reddish
O. aenescens
Thorax dark, with 4 black stripes (Sides of abdomen usually pale)
Thorax gray, with 3 black stripes (Abdomen checkered, with hip usually red, the sides never pale)
6th vein short
6th vein continued faintly to wing margin
Musca domestica
(The house fly)
Sarcophaga spp.
Fannia spp.
Hylemya, Paregle and others
Head yellow below; thorax dark striped Anterior spiracle white
Head dark below; thorax not striped
Callitroga
Squamae white or partly so
Squamae uniformly dark
Protophormia terrae-novae
Proboscis elongate, stiff, non-retractile, blood-sucking. Thorax with pale spot behind head
Proboscis normal, retractile Tip of scutellum more or less pale
Middle thoracic stripe abbreviated; wing yellowish-brown at base
C. hominivorax (=americana)
(The screw-worm fly)
Thoracic stripes of equal length; wing grayish-brown at base
C. macellaria
(Secondary screw-worm fly)
Anterior spiracle blackish Dorsal thoracic bristles strong
Anterior spiracle reddish Dorsal thoracic bristles reduced
Stomoxys calcitrans
(The stable fly)
Muscina
Legs in part reddish-brown
M. stabulans
Legs wholly black
M. assimilis
Phaenicia and allies
Pharmia regina
(The black blow fly)
Abdomen strongly shining not pollinose dorsally,* males with squamae partly darkened, eyes close set
Abdomen pollinose dorsally,* males with squamae white, eyes moderately separated
Front margin of thorax entirely shining or with occasional traces of pollinosity*
Front margin of thorax uniformly pollinose*
Body usually green Male genital segments concealed, female without variegated pollinosity ventrally on abdomen*
Body usually bronzy Male genital segments conspicuous, hairy, female with variegated pollinosity ventrally on abdomen* (bodily visible when viewed in certain light)
Antennae and palpi black or blackish
Antennae reddish
Antennae black
Lucilia illustris
P. eximia
Bufolucilia silvarum
Antennae and palpi reddish
P. coeruleiviridis
ABDOMEN
MALE SIDE VIEW
FEMALE VENTRAL VIEW
P. sericata
P. cuprina (cuprina (=pallescens))
EPAULET
BASICOSTA
SUBCOSTA
COSTA
REMIGIUM
NO'S 1-7 ARE THE "LONGITUDINAL WING VEINS" USUALLY REFERRED TO AS "VEINS"
ANTERIOR SPIRACLE
SCUTELLUM (BETWEEN WINGS)
4th VEIN OF WING
EYE
ANTENNA
PALPUS
PROBOSCIS
SQUAMA
HIND LEG
HEAD THORAX ABDOMEN
THORACIC STRIPES AND POLLINOSITY ARE BEST OBSERVED IN POSTERO-DORSAL VIEW
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Training Branch
Atlanta, Georgia
1951 – Revised July 1958
USUAL DIFFERENCE IN INTEROCULAR SPACE OF MALE AND FEMALE FLIES
FEMALE
MALE
ANTERIOR VIEW
*"POLLINOSE" REFERS TO A WHITISH DUSTING OF A SURFACE CAUSED BY MICROSCOPIC HAIRS

DIPTERA: PICTORIAL KEY TO PRINCIPAL FAMILIES OF PUBLIC HEALTH IMPORTANCE

H. R. Dodge


Antennae of 3 segments or the apical segments more or less fused
Antennae of 10 or more distinct segments, usually elongate
4 or 5 posterior cells
Not more than 3 posterior cells (Antennae 3 segmented)
Antennae short, of 10-11 segments. Posterior veins fine
Antennae 12-16 segmented, elongate. Posterior veins not unusually fine
SIMULIIDAE
3rd vein with 3A long, 3B ending behind wing tip
3rd vein with 3A short, 3B ending before wing tip
Abdomen flattened - TABANIDAE
Abdomen cylindrical - RHAGIONIDAE
STRATIOMYIDAE
A. Costa ending before wing tip.
B. Wing veins reduced.
C. Vestiture of wing very sparse.
Wing with costa continued around apex and veins numerous, thickly clad with hairs or scales
HELEIDAE (= CERATOPOGONIDAE)
A. 2nd antennal segment with seam.
B. Mesonotal suture complete
A. 2nd antennal segment without seam.
B. Mesonotal suture incomplete or absent
Wing with cross veins at about the middle
Wing without cross veins beyond the basal third
CULICIDAE
PSYCHODIDAE
Hypopleura bare, or with sparse, fine hairs
Hypopleura with a row of strong bristles
Hypopleura with long, usually dense hairs. Mouthparts vestigial
Postscutellum undeveloped
CUTEREBRIDAE
Postscutellum large, swollen (See fig. for TACHINIDAE below)
OESTRIDAE
MUSCIDAE
Oral vibrissae usually present. (Small flies rarely retained by a 16-mesh screen)
Oral vibrissae absent. (Size usually larger, or with prominent ovipositor in female)
Postscutellum undeveloped
Postscutellum large, swollen
LARVAEVORIDAE (= TACHINIDAE)
(Spurious vein absent. Anal cell not nearly reaching margin of wing)
A. Spurious vein present.
B. Anal cell nearly reaches wing margin
A. Anal cell short.
B. Female ovipositor prominent
Anal cell absent
SYRPHIDAE
EPHYDRIDAE
Usually four notopleural bristles
Only two notopleural bristles
SARCOPHAGIDAE
CALLIPHORIDAE
(Mouthparts well developed, functional)
Mouthparts vestigial
Clypeus broad
Clypeus narrow (Body shining black)
OTITIDAE (= ORTALIDAE)
LONCHAEIDAE
BASTEROPHILIDAE
Body dull to moderately shining
Body strongly shining, usually black
(Antennae apparently 2-segmented. Palpi not large and bristly. Posterior veins strong, with cross veins)
(Wing vein 5 without slight irregularity. Anal vein present)
A. Antennae apparently 1-segmented.
B. Palpi large, bristly. C. Posterior veins fine, without cross veins
A. Mouthparts thick, fleshy. B. 1st hind tarsal segment broad
A. Mouthparts not thick and fleshy. B. 1st hind tarsal segment long, slender
A. Vein 5 with slight irregularity.
B. Anal vein absent
A. Abdomen broad basally.
B. Front leg only slightly shorter than hind leg
A. Abdomen tapered basally.
B. Front leg usually much shorter than hind leg
PHORIDAE
BORBORIDAE
DROSOPHILIDAE
CHLOROPIDAE
PIOPHILIDAE
SEPSIDAE

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE. Communicable Disease Center, Training Branch, Atlanta, Georgia – 1948, Revised May 1953

Table 2-1. Biology of Domestic Flies

Species	Life cycle	Adult occurance	Preferred host material
House fly Musica domestica	200 – 2000 eggs per female. Egg to adult in 7 to 45 days.	Prefer warm but not too hot weather. May occur year around but most abundant in Sept. and Oct.	Larvae almost always occur in man-made sources, animal waste, culled fruits and vegetables are preferred.
Little house fly Fannia canicularis	180 – 560 eggs per female. Egg to adult in 18 to 24 days.	Males typically hover in protected locations such as garages, porches and inside houses. Less abundant during summer and winter.	Larvae develop in almost all kinds of decaying organic matter. Chicken manure usually the source of large infestations. Other types of manure also favored.
Green blow fly Phaenicia (2 species)	3000 eggs per female. Egg to adult in 9 to 18 days.	Frequently most common flies in urban situation. Common during summer months.	Garbage cans common source during summer months. Dog droppings also preferred.
Blue blow fly Eucalliphora and Calliphora	500 – 700 eggs per female. Egg to adult in 15 to 21 days.	Usually first flies to appear in the spring.	Decaying carcasses of birds and mammals. Also found in garbage dumps.
Black blow fly Phormia regina	200 – 400 eggs per female. Egg to adult in 10 to 25 days.	Most common blow fly in wild areas. Active in relatively cool temperatures in spring and summer.	Decaying carcasses. Also lays eggs in open wounds of animals
Stable fly Stomoxys calcitrans	200 – 400 eggs per female. Egg to adult in 13 to 40 days.	Common around dairies. Occasionally attracted to and bite dogs in large enough numbers to be a problem.	Manure, especially when mixed with straw. Lawn clippings and animal feed waste also preferred.
Vinegar flies Drosophila (several species)	400 – 1000 eggs per female. Egg to adult in 8 to 11 days.	Most abundant around larval source and during fall, but can be present year around.	Larvae found in decaying fruit and vegetables. Garbage cans frequent source.
False stable fly Muscina stabulans	140 – 220 eggs per female. Egg to adult in 15 to 30 days.	Most abundant in early spring prior to peak house fly emergence. Occur in many situations.	Manure and decaying plant waste such as culled fruit.
Flesh flies (several genera)	Female deposits 30 to 60 larvae instead of eggs. Eggs held in female until they hatch. Larvae to adult 8 to 18 days.	Year around, more common in warm months.	Garbage cans, manure (especially untrampled) animal carcasses including snails.

FLEAS, LICE, BUGS

I. INTRODUCTION AND MEDICAL IMPORTANCE

With this chapter we begin a study of arthopods called "Ectoparasites" meaning, literally, parasites living on the outside of an animal's body (see Key). Under Arizona conditions, fleas are second in importance only to mosquitoes in regard to disease transmission. Fleas are vectors of the Plague organism from wild animals to man. In addition to its disease potential, the flea bite can cause severe discomfort and irritation.

Plague is not the only disease of importance transmitted by fleas in the United States. Murine typhus, dwarf tapeworms, and dog tapeworms are transmitted by fleas; but the importance of these latter diseases in Arizona is questionable.

II. FLEAS

A. CHARACTERISTICS

Fleas are small, wingless, brownish and glossy insects (see diagram). The hind legs are longer and fitted for jumping. The body is laterally compressed to enable the flea to move easily in hair or fur. Both adult sexes take blood and the female requires it to lay viable eggs. The mouthparts are of the piercing-sucking type. Most fleas are rather host specific. The cat flea, however, has a wider host range, and both cat and dog fleas readily bite man. Not all fleas are efficient vectors of plague and this characteristic, plus their host specificity, probably spares many persons from becoming infected.

B. IDENTIFICATION

Identification of fleas is impossible without a good microscope. The principle characteristics used are heavy spines or bristles called comb teeth or ctenidia, the number of rows of setae on abdominal segments, and other microscopic details on various parts of the body. A key of the more common fleas is provided for your convenience. Larvae of fleas are minute, whitish, wormlike larvae and attempted identification at this stage of development is not recommended.

C. LIFE CYCLE-FLEAS

The flea goes through complete metamorphosis, so it has egg, larval, pupal and adult stages in its life cycle. Several hundred eggs are usually deposited in batches of twenty (20) or thirty (30) amongst hairs or feathers of the host. These drop off the host into the nest, hatching in about two days into small, blind, worm-like larvae. These larvae live in debris, in flooring cracks, or in bedding and nesting material, and feed on waste materials and adult flea droppings which fall from the animal. After three larval moults, ranging from a week to several months, the larva transforms into a pupa. Length of development is tied to temperature and humidity. The pupal stage lasts from a week to a year. The adult flea feeds on host blood within a day after emergence and mating takes place soon afterward. Adult fleas can exist for thirty (30) days or longer without a blood meal depending upon environmental conditions.

D. CONTROL

The epidemiology of plague is so closely related to the life cycle of the fleas, and rodents they feed upon, that a short discourse

on the subject of plague is warranted. The sequence of events in Western North American plague cases begins with an outbreak of plague amongst wild rodents. This type of plague is known as 'sylvatic' or 'wild animal' plague. Wild animals, including rodents and larger predators, often show antibody titers to the plague bacillus a considerable time before the occurrence of a die-off. Sometimes this means there has been a previous undetected epizootic amongst the population. Other times it seems to indicate that a non-virulent plague bacillus is present. Something, as yet unidentified, occurs amongst reservoirs to suddenly fan the plague into an epizootic and large numbers of rodents, often within a limited species distribution, contract the disease and die. If, during this process, a human comes into contact with the fleas, or occasionally the tissues of the infected rodents, the person may become a human plague case. An epidemiologist studies the victim's movements during the period before onset of symptoms. Knowledge of the person's whereabouts will help locate the foci or origin of the plague activity.

There is an increasing pattern of transmission that revolves around domestic cats and dogs who may bring infected fleas home from hunts. Cats are affected with symptoms; dogs seldom show symptoms but will show an antibody titer. Once the foci are detected, a site visit will usually confirm sick or dying animals, or trapping activity will turn up plague positive rodents. The control consists of killing the flea vector with insecticidal dusts. This procedure usually involves placing measured amounts of dust into the rodent's burrow, or a bait station that requires the rodent to wade through

a dust bath on the way to the bait. This precision application eliminates the necessity for extremely large area dusting of the environment, which has been used with questionable results.

As the above indicates, flea control incorporates the dusting of the animal or its nesting habitat. Since fleas, during their life cycle, occur in both situations, it is necessary to treat each in order to complete the flea control.

III. HUMAN LICE

A. CHARACTERISTICS

Lice, in general, are closely adapted to their specific host, and are found not far from the host itself, or on some intimate article such as clothing or bedding. The three species feeding on humans are: Pediculus humanus corporis, the body louse; Pediculus h. capitis, the head louse; and Phthirus pubis, the pubic or crab louse. The three cause a condition known as "Pediculosis" or a disease of the skin caused by their bites and excretions.

The most significant louse from the point of disease is the body louse, which transmits epidemic typhus and relapsing fever (louse borne). Neither the louse borne form of relapsing fever or epidemic typhus are important in Arizona at this time.

B. IDENTIFICATION

Both the head and body louse are similar in appearance: elongated, soft bodied insects, about ¼ inch long. They have three pairs of legs with delicate hooks at the extremities. They are grayish white to rust colored (after feeding). The key to differentiation of the two is that the head and body louse are

found exclusively on those respective parts of the body.

Immature stages or nymphs resemble the adult except in size, but are still visible to the naked eye. The crab louse, which may be found on almost any hairy part of the body, predominates usually in the pubic region. The crab louse leaves characteristic small 'blue spots' in the skin tissue of the host where it has fed. This characteristic is often sufficient for diagnosis of the pubic louse.

Diagnosis of the head lice is based upon nits (or eggs) found on the hairs, since the nymphs and adults are difficult to find.

C. LIFE CYCLE

The life cycles of the three lice are very similar. Ordinarily eggs hatch about eight (8) days after they are laid, but eggs laid in the clothing some distance from the skin develop more slowly at low temperatures, so incubation may take up to two weeks. The lice spend about nine days in nymphal stages, moult three times and grow into adults. Crab lice may develop more slowly. About one day after emergence the females begin laying eggs and continue laying at the rate of four to five eggs per day up to their life expectancy of approximately one month.

D. CONTROL

1. BODY LOUSE

The body louse spends its life on clothing except when feeding on the human host. Eggs are attached to the cloth. Thus, control of the body louse is directed to treatment of the clothing. This may include basic hygiene and standard laundering. Where an infestation exists, the clothing should be

laundered as soon as possible after removal and not mixed with other pieces of clothing or bedding. If conditions prevent efficient laundering, there are several commercial products available, either over the counter or through prescriptions, that will aid in control.

2. HEAD AND PUBIC LOUSE CONTROL

Personal hygiene and prevention are the most important features of louse control. Towels, combs and hats should not be shared. If, however, the infestation occurs, shampooing with commercially available products (pediculocides) should be undertaken according to label instruction. Cutting of the hair is no longer necessary with the pediculocides available. There is an an additional element to the control of lice, especially of pubic and head lice. Generations of hearsay and shame have grown up around this subject. The prejudical statement, "Nice people simply don't have lice!", is erroneous since head louse infestation crosses all socioeconomic levels and has become a major problem in many schools in this state. Because of the social aspects, the discovery problem usually is prevented just long enough to spread the lice, often through common sharing of combs, brushes, and contact. Even when a child is discovered to have lice and is treated at home, he or she may be secondarily infected upon return to school, or the reverse pattern may exist. The school health nurse is a critical person in the prevention of this situation. Many schools today find it difficult to send a child home from school because the individual shows up repeatedly with lice. Likewise, it is difficult in many cases to undertake

treatment without possible legal entanglement. Therefore, Parent-Teacher groups should urge the school board in the district to pass such regulations, and the school nurse should follow up the action with adequate instructions to the parents for combatting the problem. There is more than a good likelihood that if the condition has lasted for a time, others in the home may be infested.

Treatment of a human falls into the category of medicine and the treatment of private dwellings is a function of the commercial structural pest control operator in contact with the owner. Some schools have a school nurse's fund that can assist underpriviledged families in structural pest control of the premises if this is indicated by a particularly heavy infestation.

IV. BUGS (Hemiptera)

The Order Hemiptera, like the Order Diptera, contains many different and diverse types of insects, but with certain characteristics in common. The Order Hemiptera includes the true bugs, entomologically speaking. To the general public, all insects and, for that matter, spiders, mites, scorpions and centipedes are often referred to as 'bugs'. There are two families of bugs which are of medical importance: the bedbugs (Cimicidae) and the 'Kissing bug' (Family Reduviidae).

A. BEDBUGS (Cimicidae)

1. CHARACTERISTICS

Bedbugs infest the habitations of man. Some species attack birds and small mammals such as bats and rodents and are found in their nests. The species which attacks man is

Cimex lectularis which lives in the bedding and other furniture, and when numerous even in cracks and crevices in the room. They are usually night feeders, coming out of hiding to feed on the blood of the human occupants. Heavy bedbug infestations may be detected by odor in a structure, their droppings and glands having a characteristic musty, almost petroleum odor. The importance of bedbugs in transmitting disease is very controversial. Their main damage seems to be in the intense itching and swelling they promote in biting of sensitive persons.

2. IDENTIFICATION

Bedbugs, compressed or flattened dorso-ventrally, are about four to five mm in length and about three mm in width. They are reddish brown in color. The head is broad and flat and fits rather neatly into the deeply concave anterior part of the thorax. The antennae are four segmented, the last two segments elongated and much thinner than the preceding two. Eyes are prominent and deeply pigmented. The beak is three segmented and lies in a grove reaching the middle coxae. The bulk of the insect as seen from above is abdomen and consists of eight more or less equal visible segments.

3. LIFE CYCLE

The bedbug is an example of an insect that undergoes gradual development, meaning it has an egg stage, nymphal stages which more or less resemble the adult, and an adult stage. The egg is about one millimeter long, white, elongated and slightly curved with an operculum cap at one end. The

female bedbug lays its eggs in folds of mattresses, in cracks and crevices, both on the bed and in the room. The eggs are cemented in place by a cement secreted by the female and with the opening or operculum of the egg up. One to five eggs per day are deposited for a period of sixty days, totaling 200 or more by a single female.

Warm weather favors hatching and temperatures of 70 or 80 degrees Fahrenheit are optimum for the development of the eggs which will hatch in six to ten days at this temperature. Temperatures below 55 degrees Fahrenheit and above 98 degrees Fahrenheit are unfavorable and the eggs will not hatch. Humidity apparently does not have a significant effect on egg hatching. The bedbug nymph emerges by pushing off the operculum. It is pale and cream colored with red eyes. On exposure to air the color darkens to a straw color in several hours. There are five nymphal instars with five moults to the adult stage. A blood meal is necessary before each moult and lack of this feeding will prevent the insect from proceeding to the next instar. Well-fed nymphs may mature in 35 to 45 days; poorly fed ones take over 150 days. Under optimum temperatures and conditions the life cycle may take five to eight weeks.

After the fifth moult the bedbug is a sexually mature adult and can reproduce. Mating may take place at any time but the female requires a blood meal prior to egg laying. One male may fertilize several females. More than one fertilization per female is required for maximum egg production.

There are three or four generations per year.

Under favorable conditions bedbugs can survive over a year without feeding, while well fed bedbugs will live six to eighteen months or more. They prefer feeding on man but will and do feed on most domestic animals, poultry and birds.

4. CONTROL

Bedbugs are spread not so much person to person, but in the furniture, bedding and other furnishings. Motels and hotels may be infested and luggage will carry the bugs to a new location. Good sanitation, washing of bedding and sterilization of used furniture are the best controls. Prevention or repair of cracks and crevices is well advised. Crack and crevice treatment with pesticides can be undertaken along with sterilization of bedding and furniture. More frequent treatment with safer, short residue materials may be necessary if sterilization equipment is not available.

B. KISSING BUG, CONENOSE BUGS (Reduviidae)

1. CHARACTERISTICS

There are nine species of kissing bugs known in the United States, many of them in the Southwest. All are blood suckers, feeding on birds and mammals. There are many other plant juice sucking and predaceous members of the family that are involved in occasional human bites. The plant feeders often inflict a much more painful bite than the true blood-suckers. Like their counterparts, the bedbugs, kissing bugs often remain hidden during the day and attack at night. They are frequently found in poultry houses. Infected kissing bugs

can transmit a protozoan disease called Chagas disease. This disease is transmitted from dogs, cats, rats, and other small animals to man. In the United States only a few cases of the disease have been confirmed. Southern Arizona is the most likely part of the state to have incidence of this disease, although the bugs have been found statewide in packrat burrows and elsewhere.

2. LIFE CYCLE

Like all true bugs the kissing bugs undergo incomplete metamorphosis, egg to nymphal stages to adult. One hundred to three hundred eggs are laid by the adult female, hatching in two to three weeks. There are usually five moults with a blood meal taken between moults. Nymphs become adult in one or two years.

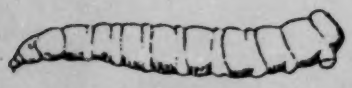
3. CONTROL

Removal of harborage and elimination or discouragement of wild birds and rodents are all good environmental steps. Keep windows, screens and doors tightly closed. Residual pesticides or more frequent treatments with non-residual pesticides will help prevent reinfestation.

HUMAN ECTOPARASITES: KEY TO COMMON GROUPS

Chester J. Stojanovich and Harold George Scott

legs absent

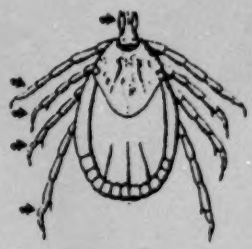


FLY LARVA
Order Diptera

legs present

head definite
3 pairs of legs

head indefinite
4 pairs of legs

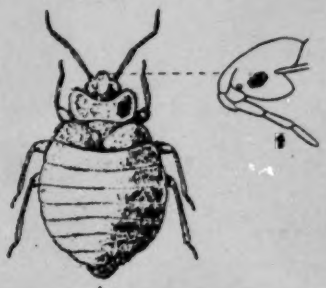


flattened laterally

FLEA
Order Siphonaptera

flattened dorsoventrally

beak jointed



beak not jointed

wings present

KISSING-BUG
Order Hemiptera

wings absent

BED BUG
Order Hemiptera

mouthparts projected

LOUSE-FLY
Order Diptera

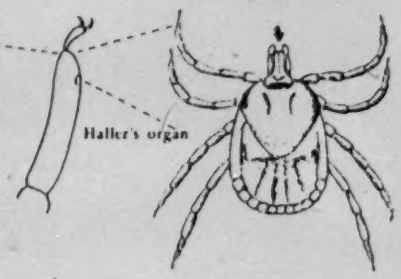
mouthparts retracted

LOUSE
Order Anoplura

over 4 mm. long; Haller's organ present

mouthparts ventral

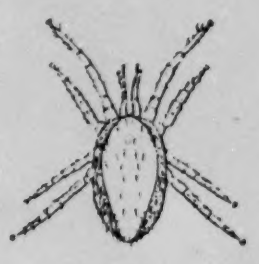
mouthparts anterior



SOFT TICK
Order Acarina

HARD TICK
Order Acarina

under 4mm. long; Haller's organ absent



MITE
Order Acarina

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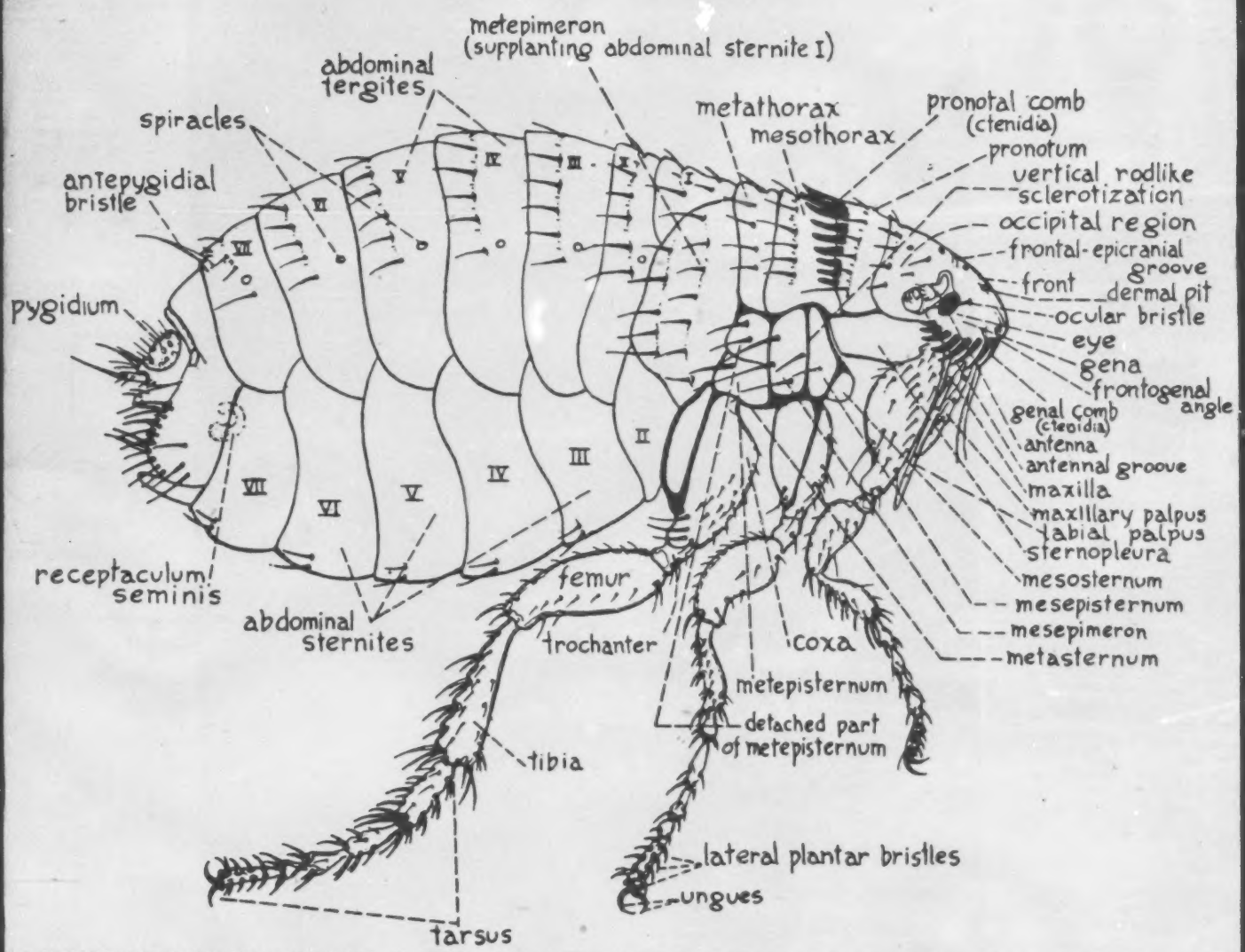
PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1962

CAT FLEA – CTENOCEPHALIDES FELIS
adult female



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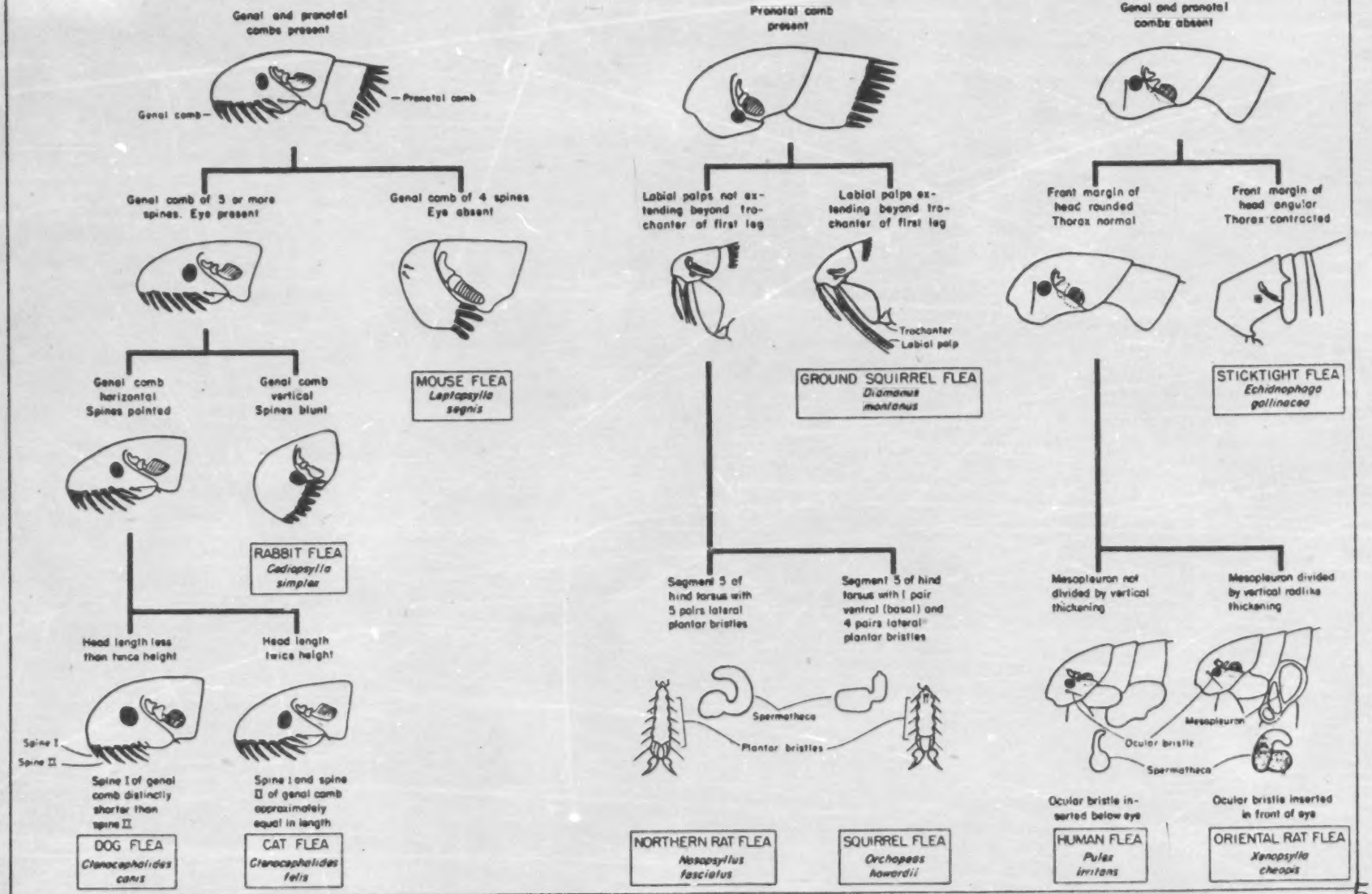
FLEAS: PICTORIAL KEY TO SOME COMMON SPECIES IN THE UNITED STATES

Harry D. Pratt


Genal and pronotal combs present
Genal comb
Pronotal comb
Genal comb of 5 or more spines. Eye present
Genal comb of 4 spines Eye absent
Genal comb horizontal Spines pointed
Genal comb vertical Spines blunt
MOUSE FLEA Leptopsylla segnis
RABBIT FLEA Cediopsylla simplex
Head length less than twice height
Head length twice height
Spine I
Spine II
Spine I of genal comb distinctly shorter than spine II
Spine I and spine II of genal comb approximately equal in length
DOG FLEA Ctenocephalides canis
CAT FLEA Ctenocephalides felis
Pronotal comb present
Genal and pronotal combs absent
Labial palps not extending beyond trochanter of first leg
Labial palps extending beyond trochanter of first leg
Trochanter
Labial palp
GROUND SQUIRREL FLEA Diamanus montanus
Segment 5 of hind tarsus with 5 pairs lateral plantar bristles
Segment 5 of hind tarsus with 1 pair ventral (basal) and 4 pairs lateral plantar bristles
Spermatheca
Plantar bristles
NORTHERN RAT FLEA Nosopsyllus fasciatus
SQUIRREL FLEA Orchopeas howardii
Front margin of head rounded Thorax normal
Front margin of head angular Thorax contracted
STICKTIGHT FLEA Echidnophaga gallinacea
Mesopleuron not divided by vertical thickening
Mesopleuron divided by vertical radlike thickening
Mesopleuron
Ocular bristle
Spermatheca
Ocular bristle inserted below eye
Ocular bristle inserted in front of eye
HUMAN FLEA Pulex irritans
ORIENTAL RAT FLEA Xenopsylla cheopis

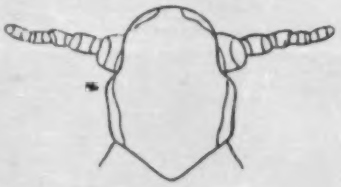
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1956

ANOPLURA: PICTORIAL KEY TO SOME COMMON GENERA OF SUCKING LICE

Chester J. Stojanovich and Harry D. Pratt

with eyes or ocular points

without eyes or ocular points



ocular points present, eyes absent

Haematopinus

eyes present, ocular points absent

Pthirus

abdomen with lateral plates

Solenopotes

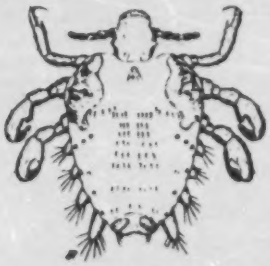
abdomen without lateral plates

Linognathus

without hairy tubercles

Pediculus

with hairy tubercles



sternal plate well-developed

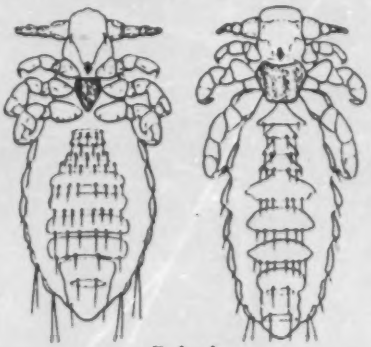
sternal plate narrow or absent

2 groups of 2 or 3 stout spines present at base of abdomen

Haplopleura

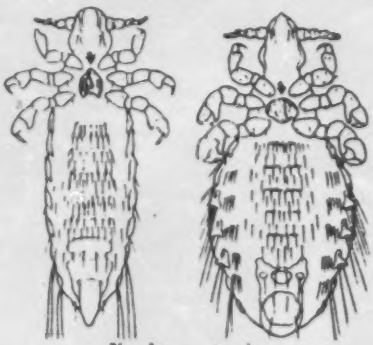
2 groups of 2 or 3 stout spines absent at base of abdomen

front of sternal plate not rounded



Polyplax

front of sternal plate rounded



Neohaematopinus

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BUGS: PICTORIAL KEY TO SOME SPECIES THAT MAY BITE MAN

Harry D. Pratt and Chester J. Stojanovich

wings usually well-developed; body elongate-oval

ASSASSIN AND KISSING BUGS–FAMILY REDUVIIDAE

thorax with cog-wheel crest

WHEEL BUG
Arilus cristatus

thorax without crest

fore-wing with 2 yellow spots

CORSAIR
Rasahus biguttatus

fore-wing dark in U. S. species

antenna inserted midway between eye and tip of head; beak slender, straight

KISSING BUG
Triatoma spp

antenna inserted near eye; beak stout, curved

pronotum constricted behind middle

BLACK BUG
Melanolestes picipes

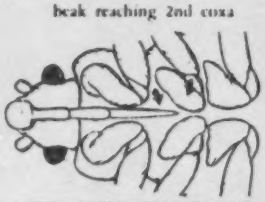
pronotum constricted before middle

MASKED HUNTER
Reduvius personatus

wings reduced; body broadly-oval

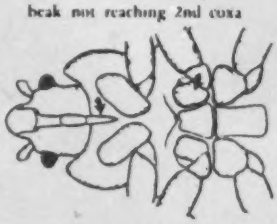
BED BUGS–FAMILY CIMICIDAE

middle coxae nearly touching
beak reaching 2nd coxa

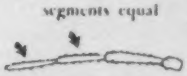


POULTRY BUG
Haematosiphon inodorus

middle coxae widely separated
beak not reaching 2nd coxa



3rd and 4th antennal segments equal



BARN SWALLOW BUG
Oeciacus vicarius

4th antennal segment shorter than 3rd

fringe hairs on pronotum longer than, or equal to, width of eye

BAT BUGS
Cimex adjunctus E N AM
Cimex pilosellus W N AM

fringe hairs on pronotum shorter than width of eye

pronotum with anterior margin moderately excavated

TROPICAL BED BUG
Cimex hemipterus
SO. U.S. & TROPICS

pronotum with anterior margin deeply excavated

BED BUG
Cimex lectularius
TEMPERATE AREAS

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PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1962

TICKS AND MITES

I. INTRODUCTION

In this chapter two groups of arthropods will be discussed. They are included together because they both share a major distinction: they are not insects. Taxonomically speaking, they are more closely related to spiders.

II. TICKS

A. IMPORTANCE

1. PARASITES

The food of both sexes of adult ticks and all active immature stages is blood, tissue fluids, and cellular debris. Most higher animals and especially mammals are attractive to ticks.

So important is blood loss from this cause amongst large animals that there is a clinical veterinary term called 'tick-host anemia'.

Tick feeding can cause dermatitis (itching, inflammation, and ulceration) at the site of feeding. This dermatitis can be caused by the trauma of the feeding process, or by toxic salivary fluids injected at the site.

Another result of feeding or attachment of ticks is a condition called 'tick paralysis'. Not much is known of the cause of this condition of ascending, flaccid paralysis except that in its early stages it can be reversed simply by removal of the tick. There have been several cases amongst humans. In

these cases the tick was often found feeding just under the hair at the base of the skull. Most tick paralysis in the United States has been associated with Dermacentor andersoni. The condition is probably rare in Arizona.

2. DISEASE

Tick transmitted disease in the Southwestern United States includes Colorado Tick Fever Virus, Rocky Mountain Spotted Fever (a rickettsial disease), Tick-borne relapsing fever (a spirochete bacterial disease). Several diseases of veterinary importance have been attributed to ticks and ticks may play a role in Q Fever and Tularemia in the West.

B. CHARACTERISTICS

Ticks are easy to distinguish from insects. In adult and nymphal ticks there are eight legs (larval ticks have six legs). Unlike insects, ticks show no apparent segmentation of the body, no well-defined head, thorax, or abdomen.

Most of the identifiable characteristics of ticks relate to the mouth part bearing structure, called a Capitulum (roughly corresponding to the head), and the presence or absence of eyes, mottling on the dorsal covering (scutum), and various grooves or creases on the posterior/dorsal abdomen (festoons) or ventrally. The ticks are divided into two large groups (families) based upon the presence or absence of some of the above characteristics.

C. IDENTIFICATION

Tick identification is not as difficult as in some arthropods, since most of the characteristics are readily visible under low magnification. The keys provided by the Center for Disease

Control identify important characteristics. The two ticks most commonly necessary to differentiate in Arizona are the very common Brown Dog tick (Rhipicephalus Sanguineus) and the less common but medically important Rocky Mountain Wood Tick (Dermacentor andersoni).

D. LIFE CYCLE

Generally speaking, ticks have a fairly wide host range. All ticks pass through four life stages: egg, larva, nymph, and adult. They pass through these life stages within a period of time from six weeks to three years.

Tick eggs are generally well adapted to withstand harsh conditions. They are least resistant to desiccation. When they hatch, the newly emerged larval tick will climb vegetation to reach passing animals.

The tick now completes a series of feedings and moltings until it becomes an adult. Host selection varies greatly amongst tick species. If the larval to adult sequence is completed on one animal, the tick is called a one host tick. If it takes two hosts, a two host tick; three hosts, a three host tick. Some ticks require up to five hosts and may utilize a variety of species. For instance, the three host tick D. andersoni utilizes smaller mammals for the larval and nymphal stages, the tick dropping off after feeding in each instance. It then transforms into an adult and generally chooses a larger animal (such as man), then drops off and lays its eggs. Multiple host ticks are important in disease transmission.

Ticks have remarkable longevity--some lasting for years under starvation conditions. Unlike insects, control measures

designed for ticks should discount much population loss due to short natural life span. Ticks are also quite resistant to submersion. Records show a three week submersion of an adult tick without apparent harm. The eggs can stand a much longer submersion.

E. SURVEILLANCE

Ticks may be recovered from animals by visual survey. To properly detach a tick, a pair of fine forceps is inserted under the tick and attached to the mouthparts. By pulling the tick mouthparts out cleanly there is less danger of injury to the host. Never grasp the tick body with the bare fingers. Some diseases are transmitted from the body secretions to the wound left by the mouthparts.

A drag may be made of white flannel cloth approximately one yard by one and one-half yard attached between a short cord to a yard long stick. The cloth is pulled slowly along over low vegetation beside roads and paths allowing the waiting ticks to attach themselves. To make the survey more standard, a path of about fifty feet is usually decided upon and then the ticks are removed and placed in alcohol. A new variation utilizes CO_2 from dry ice to attract ticks to a cloth or metal trap.

Site surveys are also used but are less productive since they require intensive searching for harborage sites, such as cracks and crevices, animal bedding and carpeting. Outdoors, the sites would include cracks in walls, sidewalks and plant material.

F. CONTROL OF TICKS

The only tick commonly encountered in Arizona in the usual domestic environment is the Brown Dog Tick (Rhipicephalus sanguineus). There is very little that can be done to control this

tick other than using pesticides. Since the tick depends upon domestic dogs to complete its development, the animal, its bedding, its outdoor haunts, and the interior of the building must all be treated. There are several 'over the counter' chemicals available for treatment of this tick. The Brown Dog Tick is so well established in parts of Arizona that getting rid of one's pet dog will do little except remove the tick from view. There is increasing evidence that the Brown Dog Tick in Phoenix, Arizona, at least, may be developing an anthropophyllic (man loving) strain.

The control of other ticks will involve either chemical treatment of the livestock host, or barrier type treatment of vegetation in a limited area.

Standard repellents (for example, Diethyl toluamide or DEET) applied to clothing may help humans who must enter 'tick country'.

III. MITES

A. IMPORTANCE

1. PARASITES

Several types of mites are parasites of man and animals. They may cause dermatitis by their feeding activity. Some mites, the so-called 'itch' and 'mange' mites, actually burrow into skin, bringing not only trauma from their initial activity, but also a sensitizing antigen that may cause an allergic reaction.

2. COMPETITION WITH FOOD SUPPLY

There are also several mites that contaminate man's food or attack his poultry and livestock. The mite fauna of stored food arecomplex. Some are primary invaders, that is, they feed

upon starches, sugar, grains, dried fruits and meats. Others are included in the overall food complex but are merely mycetophagus (feed on fungus). Other mites in food may be predaceous on other mites, while others may be only parasitic, using stored food insects as a host. Others are merely free living in the food.

Fowl mites are bothersome to poultry and sometimes become pestiferous to man. Domestic livestock is bothered by various types of mange mites that cause weight loss and loss of vigor. Control of all of the above food infesting mites is important as another cost elevating factor.

3. DISEASE

Although there are some severe mite transmitted pathogens in parts of the world, and arbovirologists have explored some mite involvement with various viruses, mites are not considered important vectors of human disease in Arizona.

B. CHARACTERISTICS

Mites bear a striking resemblance to ticks. The principal difference in appearance is size. Other characteristics are summarized in Table 1.

Certain names of body parts in mites are different from insects and ticks. The mouthparts of mites are highly specialized. The term chelicera refers to a pincher type claw on an arm. Sometimes mouthparts are reduced to a spearlike stylet. Peritremes are tubes attached to the spiracles. In some mites there is an additional plate, an elongated ventral structure. This thin, bifurcate (forked) structure beneath the hypostome is called a tritosternum.

Mites vary in color from nearly transparent to bright red. Most parasitic mites are difficult to see. Identification is difficult without special optics and exact identification is often left up to the specialist (Acarologist).

C. TAXONOMY

Keys are provided for field level identification. The reader will note that a certain amount of information about the source of infestation will be invaluable in using the keys. The type of information needed should include whether the mites were collected from food, or from animal sources, and if from an animal, what species. If the mite was collected from vegetation, or some other non-host source, the mite will likely not be found in these keys and is presumably a plant parasite or a non-important mite. The field biologist is encouraged to send important specimens in suitable preservative (i.e., 70% alcohol) to a specialist. Note that the clover mite (Bryobia praetiosa), though not of public health importance, is included in the keys because it often appears in large numbers to the consternation of homeowners and businessmen. This mite can often be recognized quickly by its extremely long first pair of legs.

D. LIFE CYCLE

There is so great a diversity in this group of arthropods that a generalized life cycle is impossible. Stages in the life cycle of a mite are: egg, larval (six legged) and the eight legged nymph and adult. There are often several nymphal stages. In most cases the life cycle is completed in less than a month.

E. SURVEILLANCE

Mites can be recovered from foodstuffs by use of a Berlese

funnel. This device consists of a funnel with a screen across the large end to hold the foodstuff, while a strong light source or other repellent (for example, moth crystals) slowly drives the mites downward into a collecting jar (filled with 70% alcohol) attached to the small end of the funnel. The Berlese funnel can be used to separate mites from any coarse material, such as bedding, nests, or litter.

Mites can be recovered from live animals by inspection, or by penning the animal or bird over a collecting bath.

Scabies mites are surveyed by scraping a sample of flesh from the suspected lesion. The scraping is cleared for a few minutes with 10% KOH or NaOH and mounted on a microscope slide. A compound microscope is needed for identification. Killed rodents and birds may be surveyed by placing them in a jar with water and detergent. The jar is shaken vigorously one hundred times and poured through filter paper, where the mites can be isolated. Mites suspected to be hidden in grass or other vegetation may be surveyed by dragging a petroleum jelly coated slide over the vegetation. The mites will be trapped on the sticky surface.

There are certain stages of internal parasites that attack swimmers and bathers in lakes and ponds. The effects of these parasites are often mistaken for mite infestations. A water sample should be taken and examined under indirect lighting to attempt recovery of the mites, or parasites.

F. CONTROL

The best control for animal infesting mites is to get rid of the birds or rodents carrying the mites, or to get rid of

the abandoned nests. Food infesting mites usually require condemnation of the food. Mites infesting animals or humans usually fall in the realm of medicine (or veterinary medicine) and should be referred to the proper specialist.

If pesticides are to be used, short residual treatments will support sanitation until the source is eliminated.

Repellents (diethyl toluamide, DEET) will offer some help to those involved with cleanup, or to those who must enter mite infested areas.

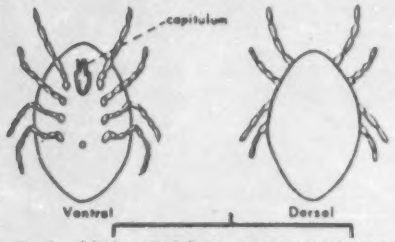
TABLE 4-1. Mites and ticks can be distinguished from each other by these characteristics.

Characteristic	Mites	Ticks
Length	Usually less than 3 mm	Usually 3 mm or more
Body Hairs	Long (in many species)	Short; few to none
Hypostome	Not Toothed	Toothed (in some stage)
Haller's Organ	None	Present (the pore is large, and on the tarsi of the first pair of legs)
Body Texture	Often membranous, or membranous with hard plates	Leathery

TICKS: KEY TO GENERA IN UNITED STATES

Harry D. Pratt

Capitulum inferior; scutum absent
FAMILY ARGASIDAE – SOFT TICKS



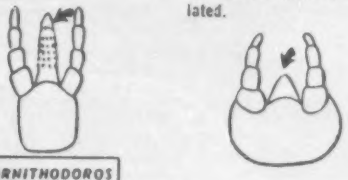
Margin of body with definite sutural line.

Margin of body thick, rounded, without definite sutural line.

ARGAS

Hypostome with well developed teeth, integument mamillated

Hypostome vestigial or without effective teeth. Integument tuberculated or granulated.



ORNITHODOROS

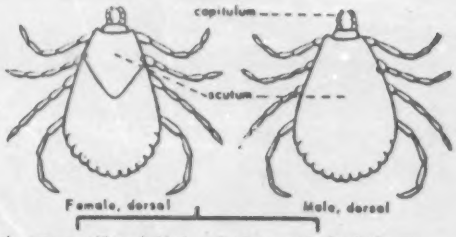
Integument of adult granular, of nymph (stage usually seen) very spinose. Hypostome of adult vestigial. Usually on cattle, horses, or rabbits.

Integument of adult and nymph tuberculated. Hypostome of adult scoop-like. Associated with bats.

OTOBIUS

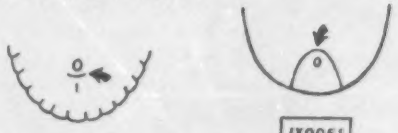
ANTRICOLA

Capitulum anterior; scutum present
FAMILY IXODIDAE – HARD TICKS



Anal groove either behind anus, indistinct, or absent.

Anal groove in front of anus.



IXODES

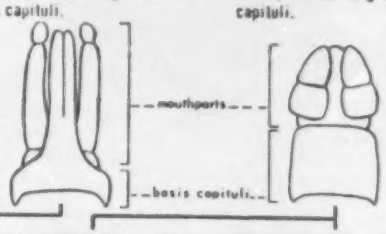
Second segment of palpi not laterally produced.

Second segment of palpi laterally produced.

HAEMAPHYSALIS

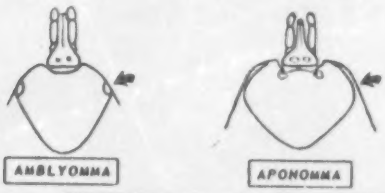
Mouthparts much longer than basis capituli.

Mouthparts as long as basis capituli.



Scutum with eyes

Scutum without eyes

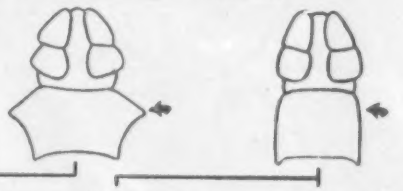


AMBLYOMMA

APONOMMA

Basis capituli laterally produced.

Basis capituli not laterally produced.



Palpi ridged dorsally and laterally.

Festoons absent.

Palpi not ridged.

Festoons present.

Festoons eleven

Festoons seven

BOOPHILUS

RHIPICEPHALUS

DERMACENTOR

ANOCENTOR (OTOCENTOR)

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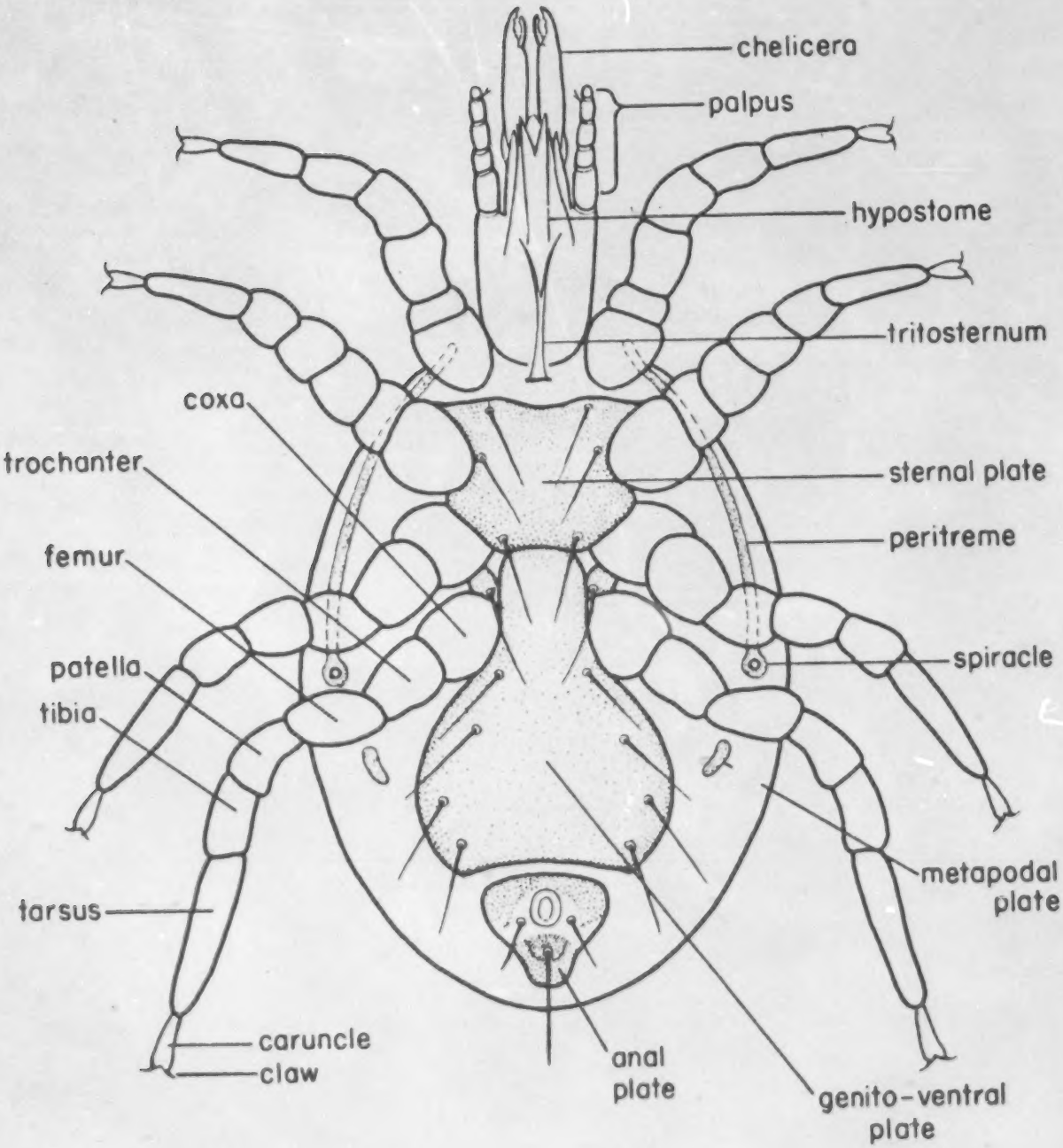
PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1961

MITE DIAGRAM WITH STRUCTURES LABELED

Harry D. Pratt



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MITES: PICTORIAL KEY TO SOME COMMON SPECIES OF PUBLIC HEALTH IMPORTANCE

Harold George Scott and Chester J. Stojanovich

U.S. DEPARTMENT OF HEALTH EDUCATION AND WELFARE
PUBLIC HEALTH SERVICE Communicable Disease Center
Atlanta, Georgia
1963

with lateral spiracles and peritreme

peritreme

spiracle

genito-ventral plate

anal plate

without lateral spiracles or peritreme

anal opening at rear of anal plate

anal opening at front of anal plate

dorsal shield undivided

dorsal shield divided

dorsal shield

CHICKEN MITE
Dermanyssus gallinae

HOUSE MOUSE MITE
Dermanyssus sanguineus

genito-ventral plate narrowed posteriorly

genito-ventral plate expanded posteriorly

TROPICAL RAT MITE
Ornithonyssus bacoti

SPINY RAT MITE
Echinolaelaps echidninus

first pair of legs very long

first pair of legs short

CLOVER MITE
Bryobia praetiosa

with club between legs I & II

without club between legs I & II

STRAW ITCH MITE
Pyemotes ventricosus

body oval with fine lines

body strongly elongate abdomen with fine lines

body somewhat elongate abdomen without lines

ITCH MITE
Sarcoptes scabiei

FOLLICLE MITE
Demodex folliculorum

A CHEESE MITE
Tyrophagus lintneri

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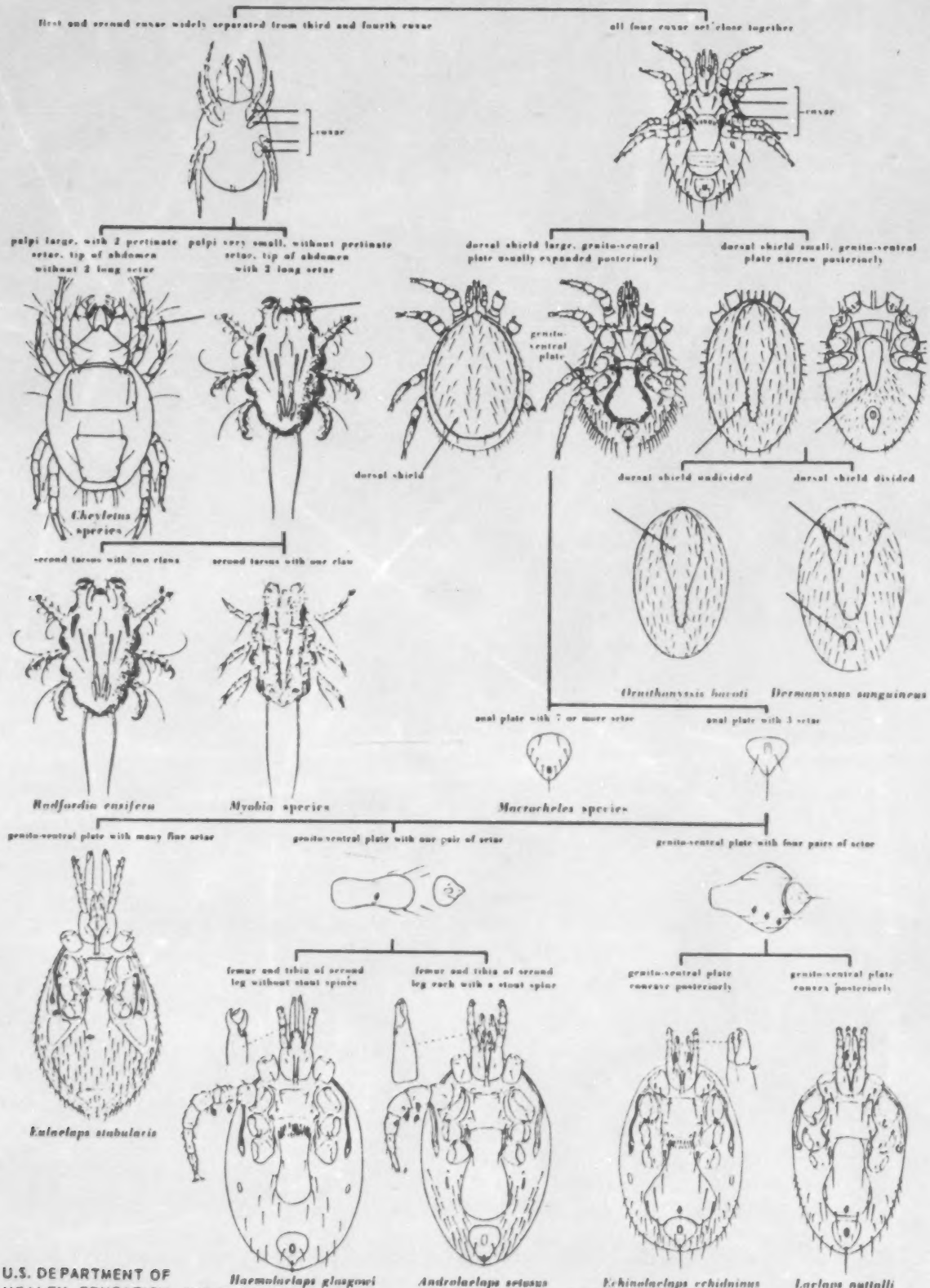
PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1963

MITES: PICTORIAL KEY TO ADULT FEMALES COMMONLY FOUND ON DOMESTIC RATS IN SOUTHERN UNITED STATES

Harry D. Pratt and Chester J. Stojanovich


first and second coxae widely separated from third and fourth coxae
all four coxae set close together
coxae
coxae
palpi large, with 2 pectinate setae, tip of abdomen without 2 long setae
palpi very small, without pectinate setae, tip of abdomen with 2 long setae
dorsal shield large, genito-ventral plate usually expanded posteriorly
dorsal shield small, genito-ventral plate narrow posteriorly
genito-ventral plate
dorsal shield
dorsal shield undivided
dorsal shield divided
Cheyletus species
second tarsus with two claws
second tarsus with one claw
Ornithonyssus bacoti
Dermanyssus sanguineus
Hadfordia ensifera
Myobia species
anal plate with 7 or more setae
anal plate with 3 setae
Macrocheles species
genito-ventral plate with many fine setae
genito-ventral plate with one pair of setae
genito-ventral plate with four pairs of setae
femur and tibia of second leg without stout spines
femur and tibia of second leg each with a stout spine
genito-ventral plate convex posteriorly
genito-ventral plate convex posteriorly
Eulaelaps stabularis
Haemolaelaps glasgowi
Androlaelaps setosus
Echinolaelaps echidninus
Laelaps nuttalli

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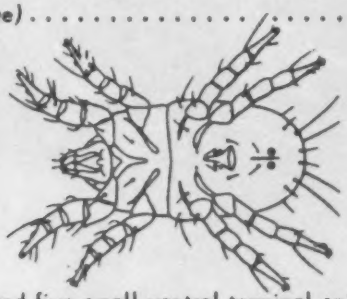
MITES: KEY TO SOME SPECIES COMMONLY INFESTING HOUSEHOLDS AND STORED FOOD

Harold George Scott

1. With club-like hair between bases of legs I and II 5
   Without club-like hair between bases of legs I and II 2

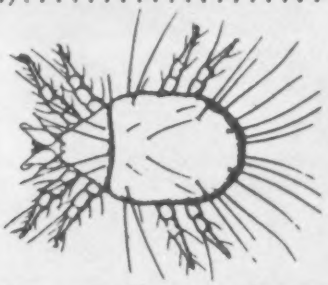
2. Claws, if present, not on stalks (*Glycyphagus domesticus*, formerly . . . . . *Glyciphagus prunorum*) . . . . . SUGAR MITE
   Claws on stalks 3

3. Internal apical hair (on joint between femur I and tibia I) less than three times as long as external apical hair 4
   Internal apical hair (on joint between femur I and tibia I) more than three times as long as external apical hair (*Acarus farinae*, formerly *Tyroglyphus farinae*) . . . . . HAM MITE



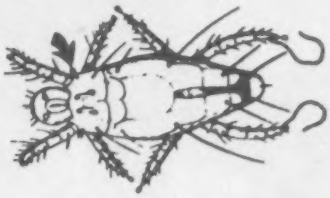
Acarus farinae

4. Tarsus with one stout dorsal and five small ventral terminal spines (*Acarus siro*, formerly *Tyroglyphus siro*) . . . . . GRAIN MITE
   Tarsus with only three small ventral spines (*Tyrophagus castellani*, formerly *Tyroglyphus longior*) . . . . . CHEESE MITE



Tyrophagus castellani

5. Tarsus IV of female ending in claws and a flesny protuberance; leg IV of male smoothly curved inwards (*Pyemotes ventricosus*, formerly *Pediculoides ventricosus*) . . . . . STRAW ITCH MITE
   Tarsus IV of female ending in two long hairs of unequal length; leg IV of male sharply bent (*Tarsonemus floricolus*) . . . . . FLORICOLUS GRAIN MITE



Pyemotes ventricosus

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4-15-74

VENOMOUS ARTHROPODS

I. INTRODUCTION

There are several pests encountered by vector control personnel that fall into the category of venomous or poisonous arthropods. These arthropods can be grouped into scorpions, spiders, and Hymenoptera. The venomous arthropods do not transmit a pathogen but become of health importance for a variety of reasons.

II. SCORPIONS

A. IMPORTANCE

The scorpion is an inhabitant of the desert and foothills. When dwellings are built by humans on its territory, it will inadvertently take up residence in buildings, woodpiles or other cover on the property. Since all scorpions have venom and are capable of stinging, they should be looked upon as capable of inflicting a painful wound. However, only two scorpions in the state are 'deadly' in the sense that their venom is capable of causing death in man. The two scorpions are Centruroides sculpturatus and Centruroides gertschi.

B. CHARACTERISTICS OF SCORPIONS

Scorpions have a more or less crablike appearance with a long fleshy five-segmented abdomen that terminates in a bulbous sac and prominent stinger. The common scorpions may be identified by the enclosed key provided by the Center for Disease Control. Note that identification is based largely upon body color and patterns, presence or absence of a subaculear tooth, and number of setae on stinger.

C. LIFE CYCLE

Scorpions are nocturnal arthropods that actively feed at night and hide during the day in rock piles, under bark, and in similar locations. They may be seen preying on insects and other anthropods under lights at night. The young of scorpions are liveborn and remain attached to the mother by their chelicerae until the first instar. During this stage they do not feed on prey, but later disperse and begin to feed on small insects. The scorpion may live for 3 to 5 years.

D. SURVEILLANCE

The only surveillance technique commonly used for scorpions is visually looking into their hiding places or by searching for them at night with a flashlight. Some scorpions will fluoresce under ultraviolet light.

E. CONTROL

In areas where scorpions are known to be abundant, several avoidance measures can be taken.

- Avoid walking barefoot, and shake out clothing and footwear.
- Be careful about lifting objects, large or small, that scorpions may be hiding under.
- Move beds and furniture away from walls.
- Reduce scorpion harborage by removing piles of rocks, boards, and rubbish.
- Eliminate water sources such as leaky faucets, etc.
- Reduce access into buildings by closing all cracks and crevices near the ground.

Control of scorpions by pesticides is difficult since many of the pesticides formerly used are no longer available. Chemicals are

usually applied to suspected hiding places, around foundations, and around the perimeter of the yard along walls.

III. SPIDERS

A. IMPORTANCE

Many spiders found near or in homes are completely innocuous except for their nuisance value. Most spiders are beneficial predators of other arthropods. When spiders do bite man, it is usually by accident, and seldomly used clothing or bedding may become harborage for spiders. Spiders also frequent closets, sheds, and other structures with little human activity.

All spiders, except members of two small families, have poison glands, but because of their size, habits, or natural habitat, never seriously bother man. Only two spiders in the United States are considered poisonous to man. These are the black widow spider Latrodectus mactans and the brown recluse spider Loxosceles reclusa (or closely related species). Although it is thought that Loxosceles reclusa has not yet spread to the State of Arizona, Dr. W. J. Gertsch, a specialist of spiders, has described two closely related species in the state. These are Loxosceles arizonica and Loxosceles unicolor.

According to an article in Progressive Agriculture in Arizona (December, 1968), the two Arizona species are similar in appearance to L. reclusa.

The effects of a bite of the brown recluse spider are described in an article that appeared in Arizona Game and Fish Department's Wildlife Views (August, 1969). The bite of a brown spider may at first be very mild with little or no pain. When the

pain occurs, it may vary from mild to severe, although it may not show up for hours. The first reaction is abnormal redness and inflammation in the bite area. This is followed by a blister. A zone of hemorrhage with increased hardening, and a halo of redness develops hours later. In about a week, the bite area will become progressively dark and firm to the touch, and then will darken further and mummify. At this stage there may be great pain. Later there will be ulceration followed by very slow healing of the bite area, perhaps taking several months.

Fortunately, the brown recluse spiders are very shy and reluctant to bite. In addition, the two species found in Arizona are more inclined to be outdoors than is L. reclusa. Loxosceles reclusa often frequents closets and storage areas of homes.

The bite of the black widow spider is characterized by intense muscular pain, tightness of the chest, difficulty in breathing, speech difficulty, nausea, profuse sweating, and often a rigid, board-like abdomen.

Like the brown spiders, the black widow spider is not aggressive, and will not bite readily. Apparently, most persons are bitten by this spider under one of two conditions: 1) when the spider is squeezed, such as in bedding or clothing or 2) when the female is guarding her egg case. A nearby vibration is sufficient to initiate her attack, This reaction is similar to that of rushing out to bite prey caught in the web.

Deaths due to black widow spider bites are not common but medical attention should always be promptly sought for

victims of black widow or brown spider bites. Making an incision or applying a tourniquet is probably of little or no value. Treatment requires precise medication, and the sooner treatment is begun, the better. It is desirable to try to locate and preserve the specimen even if it has been roughly handled.

B. CHARACTERISTICS

The identification of the brown recluse spider and its relatives in Arizona will be facilitated by a knowledge of the eye patterns of spiders. Whereas most spiders have four pairs of eyes in various combinations, the Loxosceles group have six eyes, appearing in three diads. The spiders are tan to brown, the body is approximately 1/3 inch long, and there is a distinct dark marking on the front part of the body that resembles a violin or fiddle with the neck of the fiddle facing backward. The male and female recluse spider are similar except for leg length. The male has longer legs. Overall, a male Loxosceles is approximately an inch across.

The female black widow spider is familiar to most people in that she has a dark brown to black globular, naked abdomen resembling a shiny marble. The male spider is very different. It does not have the characteristic black globular abdomen of the female, and although both sexes have a yellow to red hourglass underneath the abdomen, the male may also have yellow to red streaks on the upper abdomen.

C. LIFE CYCLE

The female of the brown recluse spider lays approximately fifty (50) eggs in a sac. The eggs hatch in 3 to 5 weeks

and the young mature in about 8 months. They make a web but are not dependent upon it, since they are active hunters.

The optimum development of the black widow spider from egg to maturity is 2 to 4 months under laboratory conditions. The number of molts varies and the intervening periods are not constant. Males may come to maturity in 5 molts or instars, whereas females pass through 8 instars. The black widow spider is closely associated with its web. The characteristic web of a black widow spider is more or less unorganized, feels strong to the touch, and may be strung almost anywhere where traffic is limited and where insects may be found. The male is venomous in the immature state, but the mature male does not attack its prey. The male poison apparatus becomes inactive with maturity and remains small in size.

IV. WASPS, BEES, AND ANTS

A. IMPORTANCE

Wasps, bees, and ants all belong to the Order Hymenoptera. Most Hymenoptera are considered beneficial to man. The chief difficulty with these insects arises when one of three circumstances exists:

- When a hymenopterous insect is out of place, such as when bees take up residence in a house.
- When somebody accidentally encounters an individual wasp, bee, or ant in a situation that results in a sting (or bite).
- When someone with hypersensitivity to hymenopterous venom is stung.

The inconvenience and discomfort caused by hymenopterous insect stings, or because of insects in dwellings, cannot be compared to the relatively rare occurrence of an anaphylactic

reaction that could result in death. The hypersensitive person needs individual protection, but there is very little that a public agency can do to eliminate the stinging insects to which an individual is allergic. If a person is allergic to the point that anaphylactic shock is a real possibility, the sensitized person should consider moving to an area where there would be less likelihood of contact with the insect or other allergin.

B. CHARACTERISTICS

A key to the more common wasps is included courtesy of CDC. Generally, it is more important to distinguish between certain flies (which bite but do not sting) and hymenopterous insects which can sting. Insects of the Order Hymenoptera, if winged at all, have two sets of wings, whereas flies (Order Diptera) have only a single set of wings. Ants are wingless, except in certain reproductive castes, and may be identified by the key provided.

C. LIFE CYCLE

Most Hymenoptera have a social or communal type of existence. Ants live in nests, mainly underground. The colony is made up of males, females, and workers, the latter functioning as both workers and soldiers. The ant reproductive castes usually take part in nuptial flights, in which the female mates with the strongest male. She then falls to the ground, and begins the egg laying activity that will form the new colony. Ant colonies are generally long lasting, often surviving the equivalent of one generation of men.

All of the wasps are colonial, the numbers in the

nest being extremely variable. A strong bee colony may have in excess of 50,000 members. Many wasp nests have 10,000 members, but Polistes wasps may only have about 100 individuals. The males and workers die in the fall, but the queen overwinters. In the spring, the female collects materials, builds a nest, and deposits eggs; one per cell in the new nest. The queen feeds the workers until they are able to emerge as adults and take care of her. Thenceforth, the queen acts only as an egg layer. The bee colony, on the other hand, is continually renewed, and from the beginning the queen's only function is to lay eggs. All care, construction and feeding of the colony is the function of the worker.

D. CONTROL

Wasps, bees and ants can be very objectionable when they are present around habitations, or in recreational areas. Chemical control by introduction of insecticide into the nest is usually the best method for control of wasps. This is best done at night for the protection of the operator. Ants are susceptible to appropriate pesticides introduced into their burrows. Wasps or bees coming into a yard can be trapped by placing sweets (for bees) or meat (for wasps) over a tub of water. If a cover is placed over the bait, and very near the water, the bee or wasp will usually fall into the water and drown after sampling the bait.

There are several new products on the market that utilize a chemical freezing agent and a strong pesticide to immobilize and kill wasps and bees. These reduce the risk of being attacked by wasps and bees.

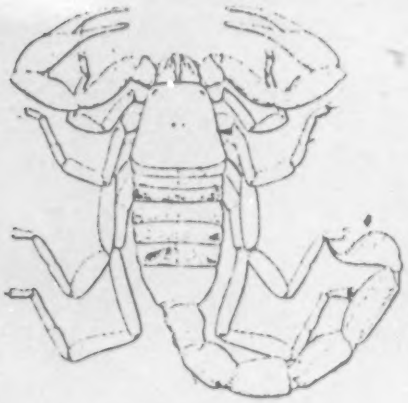
Bees are often workers from a nearby, perhaps commercial, hive. Therefore, care should be taken to avoid killing them

unless they are definitely bothering people. Often the bees will vanish as soon as the flowers they are sampling have finished blooming.

SCORPIONS: PICTORIAL KEY TO SOME COMMON UNITED STATES SPECIES

Chester J. Stojanovich and Harold George Scott

stinger with many setae



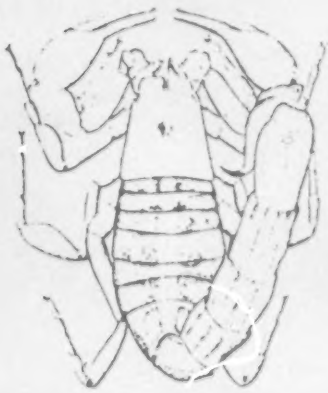
Hadrurus arizonensis
OLIVE HAIRY SCORPION

stinger with few setae

stinger without subaculear tooth

stinger with subaculear tooth

body striped dorsally

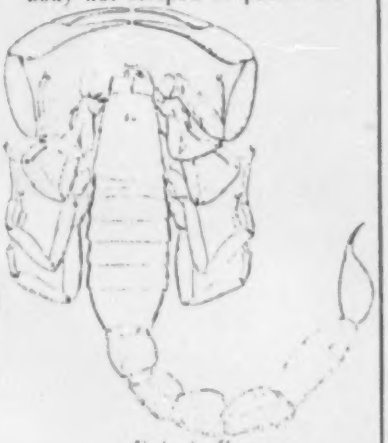


Vejovis spinigerus
STRIPE-TAIL DEVIL SCORPION

body patterned dorsally

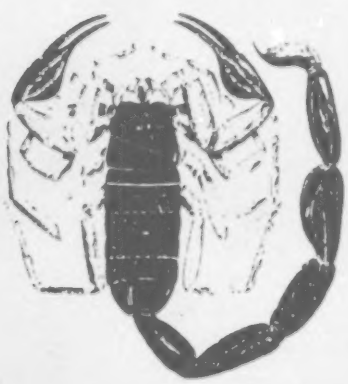
Vejovis carolinianus
SOUTHERN DEVIL SCORPION

body not striped or patterned



Vejovis flavus
SLENDER DEVIL SCORPION

body black dorsally

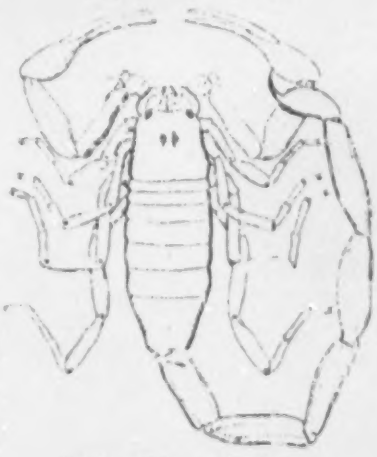


Centruroides gracilis
MARGARITE SCORPION

body striped dorsally

Centruroides vittatus
STRIPE BACK SCORPION

body yellow dorsally



Centruroides sculpturatus
DEADLY SCULPTURED SCORPION

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5-10

STINGING HYMENOPTERA:
PICTORIAL KEY TO SOME COMMON UNITED STATES FAMILIES

Harold George Scott and Chester J. Stojanovich

wings absent

body fur-like
without node

Mutillidae
VELVET ANTS

body not fur-like
with node

Formicidae
ANTS

wings present

hairs not feathered
(see 20 X magnification)

hairs feathered
(see 20 X magnification)

pronotum long, reaching tegula

Vespidae
WASPS, YELLOW JACKETS, HORNETS

pronotum short, not reaching tegula

Sphecidae
SPHECID WASPS

hind tibia with spurs

eye not reaching mandible

Bombidae
BUMBLE BEES

eye reaching mandible

Andrenidae
SWEAT BEES

hind tibia without spurs

Apidae
HONEY BEES

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PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1962

ANTS: KEY TO SOME COMMON SPECIES

Harold George Scott

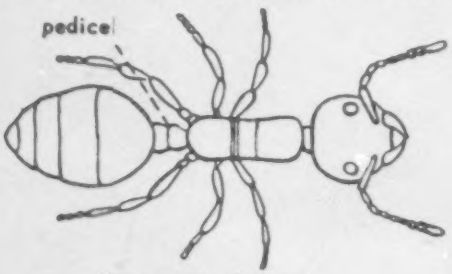
1. Pedicel ("waist") 1-segmented 2
   Pedicel 2-segmented 4

2. Petiole (scale on pedicel) poorly developed, hidden beneath abdomen (*Tapinoma sessile*) ..... ODOROUS HOUSE ANT
   Petiole well-developed, erect, not hidden beneath abdomen 3

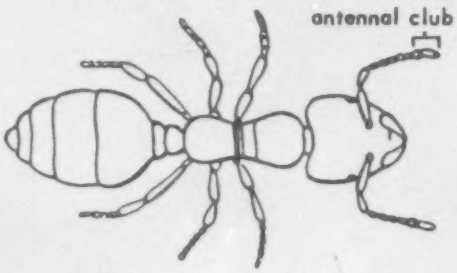
3. Tip of abdomen without circlet of hairs (*Iridomyrmex humilis*) ..... ARGENTINE ANT
   Tip of abdomen with circlet of hairs (*Camponotus herculeanus pennsylvanicus*) ..... BLACK CARPENTER ANT

4. Head and thorax with numerous spines (*Atta texana*) ..... TEXAS LEAF-CUTTING ANT
   Head and thorax spineless or with 1 pair of spines on the posterior thorax 5

5. Thorax and head covered with "fingerprints"; posterior thorax with single pairs of spines (*Tetramorium caespitum*) ..... PAVEMENT ANT
   Thorax and head without "fingerprints"; posterior thorax without spines 6



Monomorium pharaonis



Solenopsis molesta

6. Antennal club 2-segnented 8
   Antennal club 3-segnented 7

7. Shiny-black (*Monomorium minimum*) ..... LITTLE BLACK ANT
   Yellowish-red (*Monomorium pharaonis*) ..... PHARAOH ANT

8. House infesting ants (*Solenopsis molesta*) ..... THIEF ANT
   Outdoor mound-building ants 9

9. Mandibles strongly ncurved (*Solenopsis geminata*) ..... TROPICAL FIRE ANT
   Mandibles not strorgly incurved 10

10. Dorsal surface of head with large coarse, scattered punctures (*Solenopsis saevissima* var. *richteri*) ..... IMPORTED FIRE ANT
    Dorsal surface of head without punctures (*Solenopsis xyloni*) ..... SOUTHERN FIRE ANT

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PUBLIC HEALTH SERVICE Communicable Disease Center, Training Branch, Atlanta, Georgia – 1963

RODENTS

I. IMPORTANCE

In Arizona a large portion of the rodent problem is related to wild, not domestic, rodents and a widespread inability to distinguish between wild and domestic rodents (see Key). The domestic rat problem in Arizona does not appear to be as acute as it is in some other states. Nevertheless, there are documented cases of domestic rodents in many parts of the state and only constant surveillance can prevent further domestic rodent outbreaks.

II. DISEASE

Public Health importance that has been attributed to domestic rodents include Bubonic Plague, Salmonellosis, Leptospirosis, Murine Typhus, Rickettsial Pox, Rat Bite Fever, Trichinosis and Rat Bite Injury. In Arizona, wild rodents have been associated with outbreaks of Plague and Tick Borne Relapsing Fever.

The relationship of Plague to fleas has been outlined in the chapter about fleas. Because of the unique etiology of this disease and its relationship to rodents, some time will be taken to develop the latter aspect. Wild rodents vary greatly in their susceptibility to Plague. When susceptible wild rodents die from Plague, there are severe consequences for humans that encounter the residual infected fleas. This may occur because the animal died in the vicinity of the residence, because some outdoor activity brought the individual into proximity with the cadaver, or because one of man's domestic pets brought the flea vector home to the victim. It is because of these vague avenues of infection related to rodent fleas, that the observation

of animal activity becomes important in Plague control. Prairie dogs are particularly good sentinels, being both susceptible and readily visible. Their sudden disappearance should always prompt a suspicion of Plague. Because domestic rodents, especially rats, have evolved a life pattern that brings them into close contact with man, their involvement in Plague is infinitely more significant to man than that of wild rodents which instinctively avoid man, only occasionally occupying active human habitations and sharing his food.

III. BIOLOGY OF THE RAT

A. DOMESTIC RAT

This prolific rodent has a reproductive potential beginning with sexual maturity at four months of age and proceeding until its death at about six months to a year. During this period the female can produce three to six litters and the young may vary from three to twelve or more. There are recorded cases of 22 young produced by a female in her lifetime.

Domestic rat behavior is influenced by thirst, hunger, sex, maternal factors and curiosity. Rat curiosity is a beneficial factor in control of both domestic and wild rodents. These rats cannot go without water for more than two days nor without food for four days. A thirsty or hungry rat becomes desperate and easier to control.

B. WILD RODENTS

Wild rodents with their greatly varied habits are much less affected by food or water needs. Some go virtually without drinking water, obtaining it from their food, and food sources are available everywhere in the form of seeds and roots.

Both domestic rats and wild rodents become creatures of habit. They seek out the same paths to water or food, learn to avoid danger, and avoid obstacles. They are also capable of changing these habits to avoid danger or to seek new food sources.

Bait shyness is a factor in trapping methods as well as in the use of poison bait. The domestic rat will readily ingest food that is repulsive to man but will avoid many baits because of an off taste not suspected by the applicator.

IV. SURVEILLANCE

No matter whether the infestation involves domestic or wild rodents, it is important to confirm infestation with proof of existence and to gain some idea of the magnitude of the problem. Droppings are the most common evidence of rodent infestation. To an expert "scatologist" the fecal remains can help identify the species of rodent (or insect) fairly accurately as well as determine the relative size and age of the infestation (see droppings key). Runways and also rub marks (greasy areas along perpendicular walls) left by domestic rodents are extremely important to the investigator as these identify ideal trapping and baiting locations. Wild animals also leave well marked trails often along vertical cliff walls or the bases of large rocks. Trails into brushy hummocks and briars are virtual highways. In sandy areas of the state the desert floor is speckled with trails early after sunrise, most of which will disappear by dusk on windy days. Tracks in soft dirt or sand will reveal much about the activity of the animal and they, like fecal droppings, will tell what species one is dealing with. Where good tracking conditions do not exist because of lack of dust, the

investigator may supply material such as fine dust or talc.

Most wild rodents, because of their keen senses, distrust of man and nocturnal habits, are difficult to see. However, ground squirrels and prairie dogs are usually very visible in their habitat, especially if time is given for them to forget the observer's intrusion.

Visible detection of such things as Plague outbreaks are often determinable by lack of tracks or other signs of life in an area previously known to be inhabited, or by finding dead animals, abandoned burrows, or abundance of fleas in the mouth of rodent burrows.

V. CONTROL

Control of rodents cannot generally be separated from control of their fleas, at least for the sake of Public Health interests. An extensive poisoning campaign will sometimes result in large numbers of fleas being released to seek a new host. Insecticidal dusting or treatment prior to rodent control is the rule. Control of rodents by chemicals generally falls into two categories. The most popular and perhaps the safest control involves the multiple dose rodenticides. These poisons, also called anticoagulants, involve continued repeated dosages to achieve their effect. Anticoagulants have the effect of preventing the normal clotting of blood, resulting in internal bleeding and death. Bait shyness or refusal to take the bait is less of a factor in anticoagulant use because presumably the animal does not associate its own deteriorating conditions with the material it is eating. Anticoagulants include warfarin, prolin, fumarin which belong to the hydroxycoumarin group and pival, PMP and diphacin, which belong to the indandione group of anticoagulants. Readily available sources

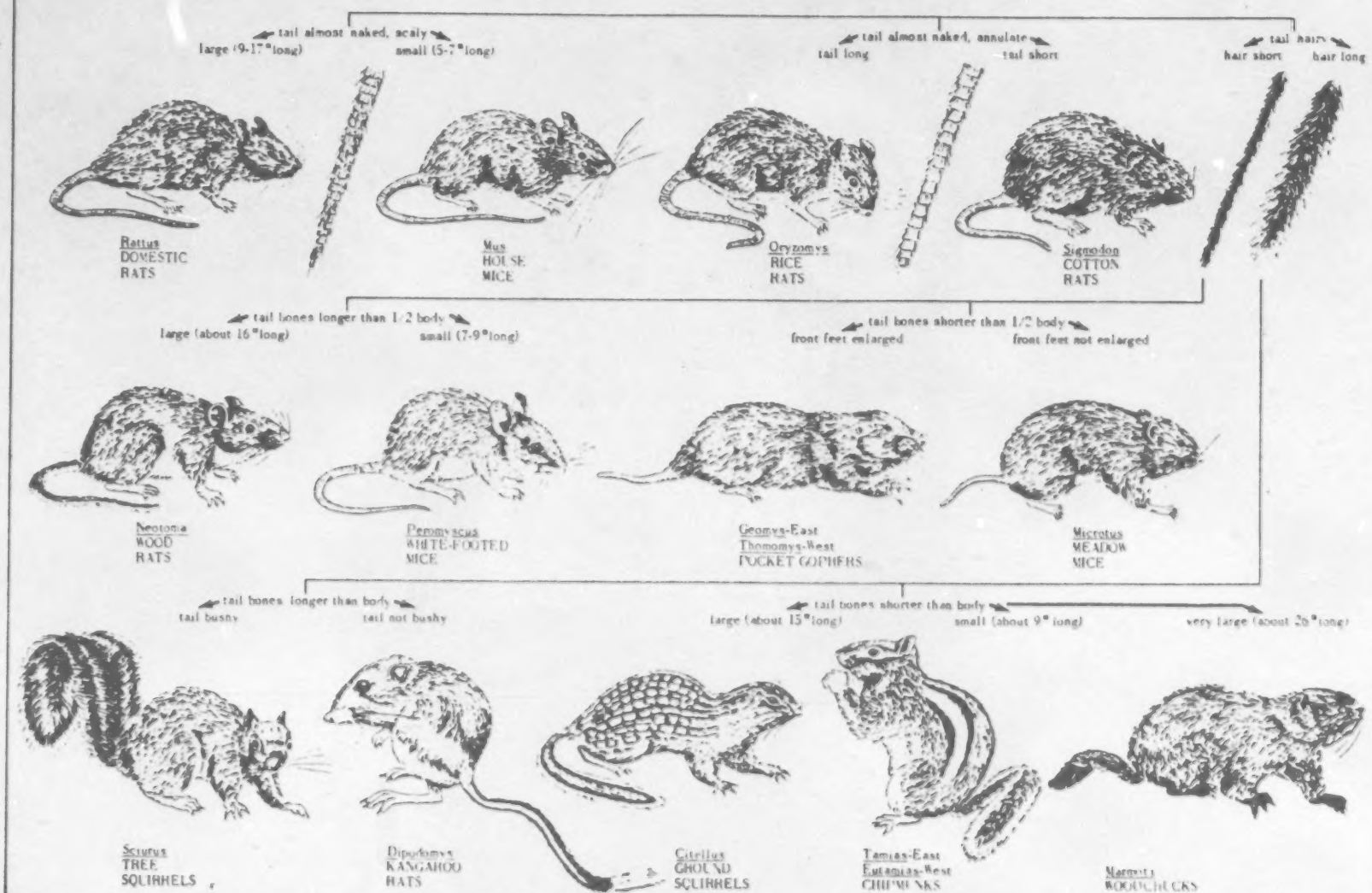
of seeds and roots supply excess vitamin K to counteract the action of anticoagulants. Additionally, anticoagulants work best where they are the food source and this is almost never the case in nature. The bait constitutes a new food source and if accepted at all is apt to be uncompetitive with more succulent vegetative parts.

The other group of rodenticides are the so-called single dose materials and are generally acutely toxic. In the past such poisons as arsenic, strychnine, yellow phosphorus, Thallium sulfate and 1080 were used, but are now considered too dangerous. The only rodenticides currently used in the single dose category are Red Squill and Zinc phosphide. Red Squill has a bitter taste and is a natural emetic, producing vomiting in all animals except the rat. Because of its bitter taste, domestic rodents will develop bait shyness to it rapidly. On exposure to air, Red Squill absorbs moisture and becomes caked rapidly. Zinc Phosphide is another acute poison. It has a pungent odor which repels birds and pets but is attractive to rodents. It kills by causing heart failure and internal damage to the viscera. It must be used with extreme care.

Perhaps the safest and most effective rodent control for a small job or limited infestation is the use of snap traps. These may be baited with damp rolled oats for wild rodents or with bacon, peanut butter, cheese or combinations of these for domestic rodents.

RODENTS: PICTORIAL KEY TO SOME COMMON UNITED STATES GENERA

Harold George Scott and Margery R. Borom



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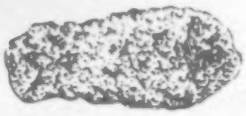
DOMESTIC RODENTS AND COCKROACHES: PICTORIAL KEY TO DROPPINGS

Harold George Scott and Margery R. Borom

length over 1/3-inch*

rectangular, blunt



Rattus norvegicus
NORWAY RAT

elongate, pointed

Rattus rattus
ROOF RAT

length under 1/4-inch*

elongate, pointed

without ridges
length about 1/4-inch

Mus musculus
HOUSE MOUSE

with ridges
length about 1/16-inch

Blatella germanica
GERMAN COCKROACH

rectangular, blunt
with ridges

ovoid, pointed
with ridges

length about 1/8-inch

Periplaneta americana
AMERICAN COCKROACH

length about 1/16-inch

Blatta orientalis — ORIENTAL COCKROACH or
Periplaneta fuliginosa — SMOKY BROWN COCKROACH

length about 1/8-inch

Periplaneta australasiae
AUSTRALIAN COCKROACH

length about 1/16-inch

Periplaneta brunnea
BROWN COCKROACH

length about 1/32-inch

Supella supellectilium
BROWN-BANDED COCKROACH

*All characteristics for average, dry, adult droppings. Study groups, not individual droppings.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, Communicable Disease Center, Training Branch, Atlanta, Georgia – 1964

APPLICATION OF PUBLIC HEALTH PESTICIDES

I. INTRODUCTION

The application of Public Health Pesticides may vary significantly in effect from either structural pest control or agricultural application. For one thing, the application is made routinely for the public benefit, but not necessarily by their personal order. Although application is done exclusively for the public good, there are many persons who violently disagree with the use of any pesticide. Additionally, for a public health representative to not only condone, but also to actually apply a pesticide may be construed by these same individuals as almost treason. There are, nevertheless, justifiable needs to utilize pesticides in the interest of Public Health. The technology of biological control, cultural control and mechanical exclusion have not advanced to the point that they can be substituted for all chemical control. Therefore, the Public Health Specialist must accede to a level of peaceful coexistence between his environment and his control of disease vectors. This imposes a special need to know the most effective and safe application techniques available.

II. EQUIPMENT

The equipment necessary to perform the functions of Public Health Vector Control is not unlike those used in other types of pest control. There are few companies that specialize in Public Health machinery. Largely, the machinery used is that of the Structural Pest Control Industry. Additionally, there is need for large, power machinery in some cases, such as in control of Encephalitis Vectors.

A. SMALL PORTABLE POWER EQUIPMENT

Small compressed air sprayers, such as backpack sprayers, are used extensively in remote locations where spot treatment is necessary. Both types are powered by compressed air from a small hand pump. The compressed air forces the liquid up through a hose and past a nozzle assembly. Depending upon the nozzle size and pressure exerted, a certain assembly will achieve a predictable result and recommended uses are included in the tables.

An extension of the extremely portable nature of the backpack is the pistol sprayer. It is very much like the gun used for dispensing window washer. A stream of insecticide is produced by pulling the trigger. The pattern can be adjusted somewhat by adjusting the simple nozzle. Because they are made of durable, inexpensive plastic, they may be afforded by the most austere of programs and, in fact, can be assigned to several individuals for "spot" treatment in urban situations. When loaded with non-toxic larviciding oils they can be safely carried in a sedan and used routinely by non-field personnel.

A word or two should be said about the portable duster. A modern, efficient and fairly expensive model of this is available. It weighs approximately fifty pounds when fully loaded. The duster consists of a small hopper for holding dust, a small gasoline motor operating a radial fan and an air discharge nozzle into which the dust is fed. Often these small portable power units are also equipped with liquid, dust, and granule capacity. Their maximum usefulness comes in applying pesticides in inaccessible places where a certain amount of dispersion is required; it is a useful

replacement for hand fogging devices. Examples of places they can be used in public health works are: swampy, overgrown areas, attics or outbuildings, from boats, or in dusting extensive animal burrows.

The older, more practical version of the hand duster is still in use for the above purpose. It is powered by a hand crank and blower system. They are very simple to use and efficient, having no parts to wear out, no fuel to purchase, and the bulk of the payload is dust, not engine. Since the machinery is crank operated, it is easy to modify the airstream velocity, and the dust that is incorporated into the air stream is regulated by a simple slide and hole setup. A word of caution is advised. If the dust venturi allows too much dust to trickle into the air tube, the residual will simply trickle out the end of the tube when it is lowered. Dust output must be carefully matched with a comfortable average cranking speed to achieve maximum efficiency.

B. POWER EQUIPMENT

In the field of mosquito and fly control, there is a need for larger volume, more wide area control, especially during Encephalitis epidemics or in the less efficient adulticide oriented spray programs.

The hydraulic power sprayers are modifications of units originally designed for field crop and tree usage. They are now chiefly used to apply liquid insecticides to swampy or marshy areas and to fly breeding spots such as manure heaps.

In this type of application, the spray pattern is developed by pressure from a power driven hydraulic pump with suitable regulator.

Pressure used ranges from 20 to 800 psi. In addition to the pressure, a nozzle is used to shape the spray fan and allow for droplet size. The latter may vary from a solid stream to a very fine mist. More discussion will be developed about this later. Holding tanks for the liquid very from approximately 50 to 150 pounds and output can be adjusted from about one to seven gallons of spray per minute.

Pressure regulators, an integral part of all power sprayers, are the most simple, yet misunderstood parts of the sprayer. Typically the regulator is a large, smooth, steel ball bearing forced against a valve seat by a spring. A nut, thumb screw, or lever adjusts the spring tension to provide high or low pressure. When pressure exceeds that desired, the ball bearing is displaced and the surplus spray recirculates through the pump or is forced back into the spray tank. Spray directed through the hose and into the spray application is either expelled through a nozzle mounted on a boom or is applied through a hand held 'orchard' gun. The tank capacity or the above cannot be greatly exceeded or the spray rig's mobility will be greatly reduced. Remember that fuel oil weighs 6.5 pounds per gallon and water weighs 8.3 pounds per gallon or 650 pounds and 830 pounds respectively for each 100 gallon addition.

The need for a heavy motor and pump and regulator may be avoided by the use of a suitable pressure tank. The design of this tank with suitable pressure releasing safety devices and structural adequacy is critical to the operation.

A 50 to 200 ft. length of hose is used; lengths exceeding this result in a considerable friction drag and loss of pressure. For the same reason a ½" internal diameter hose is preferable to a ¼" hose with the increasing lengths.

C. SPACE SPRAYS AND FOGGERS

Large, truck mounted power duster-mister combinations can be used to apply dusts, granules, sprays or mists. Like the hydraulic unit mentioned above, the basic unit is a hydraulic pump and regulator, but the spray is directed through spray nozzles into a powerfully driven air stream powered by the same motor that drives the pump. Because of the powerful fan that drives the air through the tube, the fine spray particles or dust or granules can be hurled up to 200 or 300 feet and dust a great deal further.

Fog generators are of two types, depending upon the way in which the liquid is broken up into smaller micron size droplets. In the thermal method an air cooled motor runs the blower, fuel pump and insecticide pump. Air is delivered into a combustion chamber where it is mixed with gasoline vapor and ignited, burning at the combustion temperature of 600 to 1200 F. The hot gases then pass out of the machine through a fog head or spud. The oil solution of insecticide is pumped through a particle size selector, a simple delivery valve, and then is injected into the nozzle where it is vaporized by the blast of hot gases. As the vapor mixture is discharged into the cooler outside air, it condenses into a very small droplet size fog. The delivery rate of these larger machines is from 40 to 120 gallons per hour. Micron range

of the droplets varies greatly from that of a smoke (0.001 microns) to that of a mist (50 to 100 microns). The preferred solvent for most thermal fog generators is No. 2 fuel oil. Higher priced oils have been produced and commercially pushed for this purpose, but their improvement over fuel oil is subject to question. At any rate, manufacturer's recommendations on the label are the final word.

Smaller versions of the thermal fogger use a pulse jet principle, where gasoline is burned at the rate of sixty explosions per second, an oil solution of the pesticide is forced into the tank under about 6 psi (tapped from the engine head) and regulated by a formulation valve. The particles then form and condense as mentioned above.

Mechanical fog generation takes place without heat. Here, high speed discs are used to break up the stream and mix it with air, then a blower drives the mixture out. Evidently these machines produce aerosols of remarkable uniformity.

Another mechanical or 'cold fogger' utilizes a special nozzle permitting the use of a low-pressure, large volume air source for atomizing the insecticide. Of course, the latter type has some advantages over the thermal type. Here 1) there is no visible cloud, 2) there is no heat applied to cause thermal breakdown of the insecticide and 3) water emulsions can be used as effectively as diesel fuel, which amounts to a considerable savings.

A point should be made here to clarify a misunderstanding about fog generators and misting machines. They are commonly

thought to be interchangeable, that is, a program should have either one or the other. This is not so, because each has its own use. The principle difference is the diameter of the droplet, commonly measured in microns and called mass median diameter (mmd). The reason this term has come into usage is that it is physically impossible to break the liquid into entirely uniform droplets. Therefore, there is a spectrum of produced sizes. This figure, in microns, divides the volume or mass of the spray into two equal portions, respectively, or finely and more coarsely atomized. The micron represents 1/1000 of a millimeter or about 1/250,000 of an inch. The average diameter of a human hair is about 100 microns. Mists are composed of droplets 50 to 100 microns in diameter and the droplets settle fairly rapidly to the ground. Aerosols or fogs are solid particles or droplets suspended in air ranging in size from 0.1 to 50 microns.

The effectiveness of an insecticide increases with an increase of its exposed surface. For droplets of different diameters, the volumes are to each other as the cubes of the diameters. Thus, for equal volumes of one aerosol dispersed as droplets of 50 microns in diameter and another as droplets of 5 microns in diameter, there would be 10 x 10 x 10 or 1000 times as many of the smaller droplets.

Another important result of the mass median diameter is the difference in time it takes an aerosol of various sizes to drop. Included is a chart for the reader's reference. Note that a droplet the size of 50 microns will take 16 seconds to fall one foot, could be carried 95 feet in a light (4 mph) wind, if dropped

from a standard height of four feet. On the other hand, a 10 micron droplet would take 6.60 minutes to fall and would be carried nearly a half mile in a 4 mph wind! It is easy to see how such a light particle as a thermal aerosol fog particle may never even reach the ground with wind, upward convection currents and evaporation. The principal point here is that, especially with fogs or aerosols, use in anything but optimum conditions (cool, still evenings or mornings) under Arizona conditions might prove worthless. This is most pronounced with the thermal aerosol fogs!

In usage, the lightness and drift of aerosols, fogs and dusts can be very beneficial for penetrating dense vegetation or controlled drifting of pesticides into rugged areas without roads. But the term drift is more often used in an environmentally hazardous sense. One of the most dangerous aspects of pesticide usage and the portion most often abused is that of not keeping the pesticide where it was intended.

D. ULTRA LOW VOLUME APPLICATION

Discussion of this concept is reserved for the last and is clearly separated from the other types of spray application because it is truly unique. It is defined as the application by aircraft or ground equipment of technical or undilute insecticide at a dosage rate not to exceed two quarts per acre. The key word here is technical, meaning undilute. The technical insecticide is atomized into millions of tiny droplets, the majority varying from 5 to 50 microns in diameter and dispersed evenly over the treated area. Its advantage especially for large areas is a savings in

time and money due to the small volume. For instance, 40 to 250 acres can be treated with a single gallon of technical grade insecticide. There is a reduction in the diluent, the mixing and the transportation of larger volumes of dilute sprays.

Before the reader is completely sold, a few negative points must be mentioned. The technique was originally developed for aerial usage with specially equipped planes. The technique has now been applied to ground usage with specially built ground machinery. The ULV technique is somewhat less effective in heavy vegetation. Also, car spotting or damage to automobile finishes has occurred because of the corrosive properties of the technical insecticides. A spill or maladjustment in the machinery or misapplication may result in an 'insecticidal error' multiplied many times. Such could occur in the handling of the pesticide while loading. Droplet size becomes very critical when using the ULV technique. So critical is this factor that the applicator must calibrate his machine frequently to establish droplet size. In the event of a suspected application error, the applicator may be required to present this evidence, since the manufacturer's label clearly required proper droplet size as a condition of warranty. For instance, Center Disease Control quotes the application equipment must have the minimum capability of producing droplets in the 5 to 27 micron range. Tank pressure, flow rate and condition of the nozzle must all be correct and within fairly precise ranges.

In short, ULV application has a place in Public Health pesticide application, but is generally too sophisticated for

the routine applicator and is recommended as a specialty tool for programs that have already well equipped programs and several years of experience.

E. AERIAL APPLICATION

Under Arizona conditions aerial application of pesticides should probably be considered emergency usage and will likely involve the use of ULV to combat encephalitis. In other parts of the United States, routine larviciding and adulticiding is undertaken with airplanes where massive marshes and swamps are encountered.

TABLE 7-1 TEEJET* NOZZLE SYSTEM

Nozzle Tip Number	Spray Pattern and Angle	GPM at 40 psi**	Use
50015	Flat - 50°	0.15	Residual spraying on very smooth surfaces
8002	Flat - 80°	0.20	Residual spraying on ordinary surfaces
5004	Flat - 50°	0.40	Residual spraying on porous surfaces
001	Solid - 0°	0.10	Cockroach control
TG1	Hollow cone 60°	0.20	Mosquito larviciding. Residual spraying small areas
Adjustable Cone Jet 5500-x18	Cone or stream	0.97	Mosquito larviciding where both cone and stream are desirable
Multeejet*** # 5700 50015	Flat - 50°	0.15	Residual spraying on very smooth surfaces
730039	Flat - 73°	0.039	Mosquito larviciding
000021	Solid - 0°	0.021	Cockroach control in fine homes or hotels
0001	Solid - 0°	0.10	Cockroach control

* Spraying Systems, Inc., Wheaton, Illinois 60187
** Gallons per minute at 40 pounds per square inch pressure.
*** This nozzle has four different apertures.

TABLE 7-2 APPLICATION RATES FOR TEEJET NOZZLES AT VARIOUS INSECTICIDE CONCENTRATIONS

Insecticide Concentrations Percentage	Teejet Nozzles			
	8001	50015	8002	5004
	(Insecticide deposit in milligrams/ft.^{2})			
0.3	6	9	12	24
0.5	10	15	20	40
0.625	12.5	18.75	25	50
0.75	15	22.5	30	60
1.00	20	30	40	80
1.25	25	37.5	50	100
1.50	30	45	60	120
2.00	40	60	80	160
2.50	50	75	100	200
3.00	60	90	120	240
3.50	70	105	140	280
4.00	80	120	160	320
5.00	100	150	200	400

Note: Surfaces treated at rate of 190 square feet per minute with pressure of 40 pounds per square inch.

TABLE 7-3 CLASSIFICATION OF DIFFERENT TYPES OF DISPERSE INSECTICIDES
Adapted from Brown (2), and Glasgow (12)*

Type	Size in Microns
Rain	4000 and larger
Coarse Spray	400 and larger
Fine Spray	100 to 400
Mist	50 to 100
Aerosols and fogs	0.1 to 50.0
Fumes and Smokes	0.001 to 0.1
Vapors	Less than 0.001
Coarse Dust	175 and larger
Medium Dust	45 to 175
Fine Dust	44 or less

TABLE 7-4 RATE OF FALL IN STILL AIR, AND DRIFT ON A 4 MILE-PER-HOUR WIND, OF DROPLETS OF DIFFERENT DIAMETERS
Adapted from Brown, in (2)*

Droplet Size in Microns	Type of Dispersion	Rate of Fall	Time to Fall 1 Foot	Distance Carried Downwind
400.0	Coarse Spray	1.6 m/sec.	0.75 secs.	4.5 feet
200.0	Medium Spray	71.5 cm/sec.	1.70 secs.	10.10 feet
100.0	Fine Spray	30.0 cm/sec.	4.40 secs.	23.50 feet
50.0	Mist	7.6 cm/sec.	16.00 secs.	95.00 feet
20.0	Fog	1.3 cm/sec.	1.50 mins.	538.00 feet
10.0	Fog	3.0 mm/sec.	6.60 mins.	0.44 miles
1.0	Fog	30.0 microns/sec.	2.75 hours	44.00 miles
0.1	Fume	0.3 microns/sec.	11.50 days	4404.00 miles

*From: DHEW Publication No. (CDC) 74-8273 Insecticide Application Equipment.